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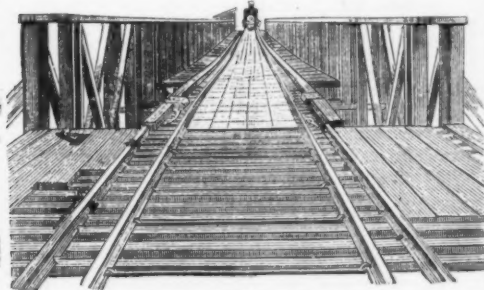
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THE RAILWAY PILE AND PONTOON BRIDGE ACROSS THE MISSISSIPPI RIVER AT PRAIRIE DU CHIEN, WIS.*

By JOHN LAWLER, C.E.

THE railway pile pontoon bridge which is the subject of this paper was built in the year 1874, across the Mississippi River, between Prairie du Chien, in the State of Wisconsin, and North McGregor, in the State of Iowa, for the purpose of connecting the divisions of the Chicago, Milwaukee, and St. Paul Railway Company terminating respectively at the points named. The river here is divided, by an interjacent island, into two channels, both of which are navigated. The McGregor channel, so called, is 1,500 feet wide at a medium stage of water, and the Prairie du Chien channel is 2,000 feet in width. The distance between the Wisconsin and Iowa shores, embracing the island to which reference has been made, is 7,000 feet, which corresponds to the length of the bridge.

The structure throughout is of ordinary piling, except across the navigable portions of the channels, which are covered by the pontoon draws. Each of these draws is a



DRAW ABOVE THE TRACK.

single float, 30 feet wide at the bottom, 6 feet deep, and 41 feet on deck, and 408 feet in length. The frame and bottom of the draw is of Norway pine, of heavy dimensions, and the deck of white pine. Each draw has five heavy bulkheads running the whole length, which are thoroughly bolted through and through. The track is regulated to the varying stages of the river by a system of blocking, confined in a frame and adjusted by means of hydraulic jacks. It may be observed that the range of variation between high and low water at this point is 22 feet. There is used in the construction of each of these draws about 600,000 feet of plank and timber.

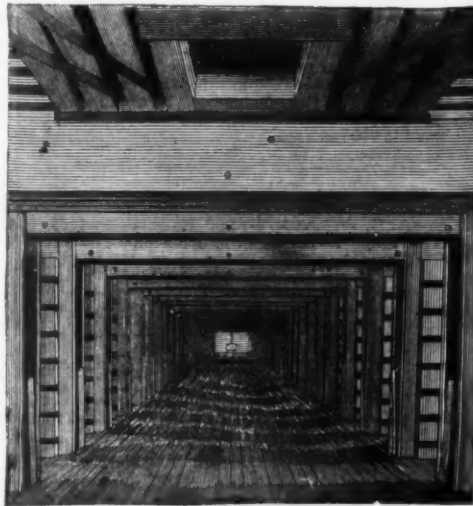
The draw is operated by a steam engine of about 20 horse power, which communicates motion to a pulling chain passing over a drum, and stretching along the bed of the river, to suitable points above and below the draw, where it is securely fastened. The pontoon, when closed for the passage of trains, is held in position by a T-shaped wrought iron shaft, 5 inches in diameter, which projects above the side of the draw into a timber frame, faced with iron and secured by a pier driven around it. This coupling, or fastening, is so arranged that it may be instantly attached or detached by a single person. The draw, when in position for the passage of trains, lies across the current of the stream at about a right angle; and when opened for the passage of river craft, comes to a rest parallel with the thread of the stream. The time occupied in opening or closing the draw is 3 minutes. The ends of each draw are adjustable to the approaches by trusses, 30 feet in length, composed of iron and of timber, by means of which the track upon the pontoon is securely connected with the permanent track. At each end of the draw shear booms rest on piers driven for the purpose, and extend at an easy angle to either shore, by means of which the largest rafts are safely guided through the draw-opening without the necessity of uncoupling.

The structure was built at about one-sixth of the estimated cost of an ordinary pivot bridge at the same point. A bridge of a similar style was erected last year across the Mississippi River between Wabasha, Minn., and a point in Wisconsin near the mouth of the Chippewa River, and Congress has authorized the building of sev-

eral others at various places on the Upper Mississippi. In concluding this paper, I desire to express my sense of gratitude to D. J. Whittemore, Esq., M. Am. Soc. C. E., Chief Engineer of the Chicago, Milwaukee, and St. Paul Railway Company, for his valuable advice and assistance during the planning and building of this structure.

DISCUSSION.

WILLIAM P. SHINN, C.E.—I would state that I spent two



VIEW UNDER THE TRACK.

weeks at Prairie du Chien about two years ago, and had occasion to observe the working of this bridge of Mr. Lawler's at quite different stages of water. There was a considerable rise in the Mississippi while I was there, I think some 10 or 12 feet, and I was astonished at the facility with which the changes were made to correspond to the changes in the water level. It struck me that the economy of that mode of construction was very remarkable—bridging a stream like the Mississippi, and at the same time providing for the passage of all sorts of craft. I think Mr. Lawler, and those associated with him, are entitled to a great deal of credit for developing that kind of engineering in connection with this great water highway.

JOHN LAWLER, C.E.—There is just one point to which I would like to draw attention. The idea of a pontoon couples with it the impression that there is a sort of disconnected series of bridges, and it might lead to the inference, perhaps, that the trains of the Chicago, Milwaukee, and St. Paul Railway, which have been transferred over it for the last nine years, must necessarily have to be detached and transferred in fragments across the bridge. I desire to im-

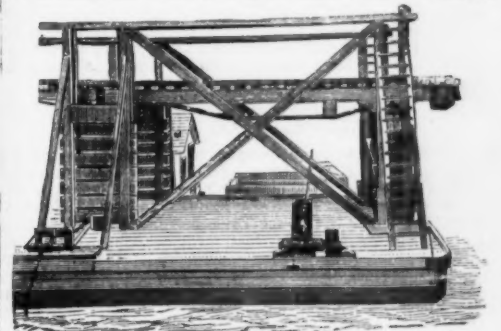
press upon the minds of the members of the Convention that such is not the case; that full trains, drawn by the largest engines owned by that company, and arriving at the points named, are transported in precisely the same manner over this bridge that they would be over any other bridge.

J. P. FRIZELL, C.E.—I would like to ask if the adjustment of the main track to the pontoon does not give rise to very steep grades?

Mr. LAWLER.—Such is not the case. The adjustments to the various levels of the water are made by the men who are otherwise necessarily employed upon the bridge, without the slightest hindrance to the trains, and, of course, without the slightest additional expense. The track is so adjusted that just previous to the passage of the train the level of the pontoon track is slightly above the level of the permanent track, so that the weight of the engine, in entering upon the pontoon draw, brings the pontoon to a perfect level.

Mr. FRIZELL.—The entire bridge is lowered then?

Mr. LAWLER.—The pontoon or draw part of the bridge

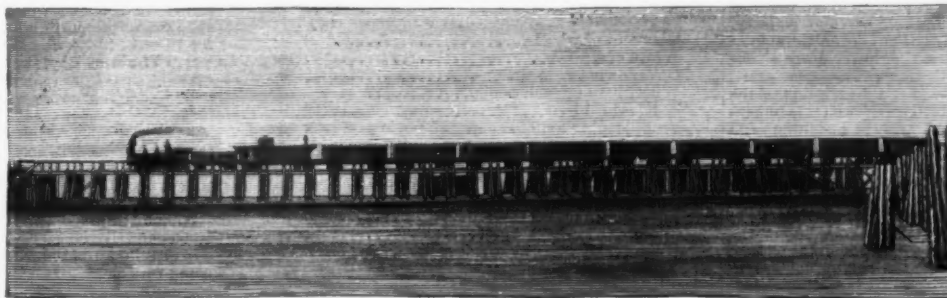


Side view, showing the projecting T fastening in position as when pontoon is closed. The shaft of the fastening projects overboard 2 feet, and when the pontoon is closed the crosspiece rests behind heavy timbers, which are framed and bolted into a pile pier. When about to open, the crosspiece is moved by lever.

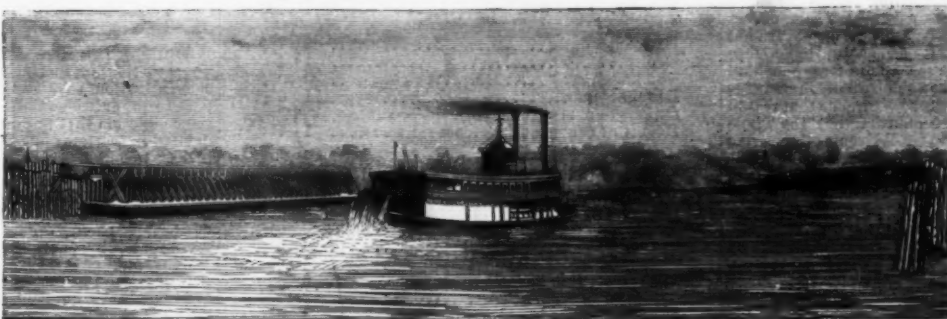
gradually settles under the passage of a train about 5 inches, but to an ordinary observer, or to the passengers on the train, this settling is not noticeable, on account of the manner in which the ends of the draw are connected with the permanent approaches of the bridge. These connections are made by two girders—one on each end of the draw—so adjusted that when the draw swings into place for the passage of a train the outer ends of the girders, which project 3 feet over the ends of the draw, are received by the permanent approaches at either end of the draw, thus affording them a solid foundation, and not only relieving the draw of a portion of the weight of the girders, and the ends of the draw for a distance of 30 feet from direct pressure, but also rendering more gradual the depression caused by the entrance of a train on the draw.

D. J. WHITTEMORE, C.E.—Mr. Lawler has very kindly referred to me at the close of his very interesting paper, and in complimentary terms that I think are not fully deserved. My remarks upon this subject will more particularly relate to the history in one marked instance of pontoons used for railway purposes.

Some of the older members present will call to mind that during the years 1848 to 1850 the Vermont and Canada and the Northern New York Railroads were under construction. These roads were built largely by Boston capital, and were intended to be operated in the interest of that city. When these lines were nearing completion it became necessary to devise some way to join them at the crossing of the outlet of Lake Champlain at Rouse's Point. The company controlling these two roads applied to the Legislature of New York for the privilege of constructing a draw span in the bridge which should connect its lines. The necessary authority for the construction of a drawbridge of any reasonable span could not be secured. The president of one of these companies was the late Governor Charles Paine, uncle of the president of this society. The chief engineer was the late Henry R. Campbell, a man of extraordinary genius and capacity, and, in my opinion, one of the most remarkable engineers of his



PONTOON RAILWAY BRIDGE AT PRAIRIE DU CHIEN, WIS.—DRAW CLOSED.



PONTOON BRIDGE, PRAIRIE DU CHIEN, WIS.—DRAW OPEN.

ILLUSTRATIONS OF THE PONTOON DRAWBRIDGE OVER THE MISSISSIPPI RIVER AT PRAIRIE DU CHIEN, WIS.

* Read at the Annual Convention of the American Society of Civil Engineers, St. Paul, Minn., June 30, 1884.—Proceedings.

time. After defeat before the Legislature of New York, it occurred to Mr. Campbell that the connection might be made by a pontoon, which should be operated by steam power, and in compliance with the legislative acts governing the operation of steamboats on Lake Champlain. A pontoon 303 feet long, about 30 feet wide, and 7 feet high, was constructed, and when it was launched, July 4, 1851, it displayed sufficient lack of wisdom to be on board. The lake on the line of railway at this point is a little over one mile wide. Pile and timber approaches were built from each shore until a space equal to the length of the pontoon intervened. Suitable aprons for adjustment of track to the varying height of water were made at the end of each approach. For steam power to operate the pontoon there was used a dismantled locomotive, having the distinctive mark "Baldwin No. 4," but known throughout the line as the "Flying Dutchman," and I believe this was the original locomotive of that name in this country. This pontoon performed its duty until April 1, 1863, and without accident of any kind, so I am informed.

Mr. Lawler has had charge of the transit of passengers and freight over the Mississippi at Prairie du Chien for the Chicago, Milwaukee, and St. Paul Railway Company for many years, and about ten or eleven years ago, in conversation with me, he said: "I ought to do this work a great deal cheaper and safer than I am now doing it by steamboat and barges, and the idea has occurred to me that I should accomplish the desired end by the agency of a pontoon." I then gave him what little knowledge I possessed on the subject.

His pontoon, however, is so radically different from any built previously that it can be well said that Mr. Lawler is not only the designer and builder of it, but its originator. He constructed his pontoon 100 feet longer than the one at Rouse's Point. He arranges the approaches so as to adjust the track to a rise and fall of water of 20 feet. In Lake Champlain the extreme rise and fall hardly ever exceeds 7 feet, if I remember rightly. There is but a slight current at the outlet of that lake, while Mr. Lawler operates his pontoon against a very rapid current. Mr. Lawler has operated this device over nine years, and without accident of any kind to either person or property. If necessity should demand it, I am positive that by Mr. Lawler's device it would be practicable, using two pontoons, to open a clear water space of 1,000 feet in a railway pontoon bridge in four minutes of time, and restore the same into position for traffic in about the same length of time.

THE FESTINIOG RAILWAY.

Among all the excursions on the programme of the autumn meeting of the Iron and Steel Institute, probably none has proved more generally interesting to the members than that of the celebrated little railway running from Port Madoc to Festiniog, which Sir Henry Tyler has described as the most instructive line in the kingdom.

The Festiniog Railway is among the oldest in the kingdom, having been constructed in 1833. It was at first used as a horse railway for the purpose of bringing down slates from the quarries of Dians, near Festiniog, to Port Madoc for shipment. In the year 1863, Mr. C. E. Spooner, C.E., the present engineer and general manager of the line, introduced a couple of small locomotives for the purpose of working the traffic. Contrary to the expectations of many these proved highly successful, and were soon followed by two others, and at the end of the year 1869 there were six locomotive engines on the line.

There is a single line of rails, and the length of main line from Port Madoc Station to Festiniog is 13½ miles, exclusive of branches. The difference in elevation between the sea level and the upper terminus is 700 ft., the ascending gradient being continuous throughout. The maximum rise is 1 in 88.69, and the least is 1 in 186. On the Traethmawr embankment, however, where the line crosses the estuary, it is nearly level. For a distance of 12½ miles the average gradient is 1 in 92. The greatest falling is 60 ft., and the deepest cutting is 27 ft. The width of the line between fences is 8 ft., and on the embankment 10 ft. at formation level. There are two tunnels, one of 730 yards through syenite, and one of 60 yards through the slate formation. Neither of these are lined. The maximum curves are 1¼ chains radius, in length from 80 ft. to 200 ft. There are others 3, 4, 5, and 6 chains, while the ruling curves are between 7 and 8 chains. The gauge of line is generally known as 2 ft., but is actually ½ in. less.

In the curves, however, the rails are somewhat spread. As may be surmised from the above particulars, the line passes through a most irregular and picturesque country. For a great part of its length it is cut out from the side of the valley of that beautiful river which lower down swells into the broad estuary of the Traeth Bach.

It would be useless attempting to give a description of the scenic beauties that are disclosed to the traveler on this romantic stretch of line, and indeed we are hardly in a position to do so. On the occasion of our two recent journeys, the weather was so thick with mist and driving rain that for most of the time it was impossible to see much more than the length of the locomotive ahead. Indistinctness, however, added considerably to the startling effects obtained during this railway mountain climbing. Looking out from the footplate of the engine we appeared to be veritably flying through the clouds, for nothing could be seen below but the rolling volume of mist. Then for an instant, as the fog lifted, a glimpse into the valley would be disclosed, and one could see that the train was speeding along a narrow ledge scarped out of the face of the rock. But it does not require the fortuitous addition of indistinctness to supply startling effects during a run on this line. In parts there are, as we have said, curves of 1¼ chains radius, and some of the sharpest bends are cut out of the face of the solid rock. It needs actual experience on the footplate to appreciate the sensation of approaching one of these curves, especially when the base of the cliff is hidden in mist. One wants then all the assurance that reason supplies to avoid an instinctive conclusion that the whole train is about to leap bodily into space. Even as the engine sweeps round the curve it is difficult to realize how it is done, for the long boiler of the Fairlie engine still points at an angle of 20° to 30° to the line into the valley which we know underlies the mist below. Of course the narrow gauge, combined with the double bogie of the Fairlie engine, is sufficient explanation for all this, but one wants to travel on the Festiniog Railway in a fog to fully realize the utmost the bogie system is capable of in taking curves.

When the line was remodeled for steam traffic, the whole of the curves were laid out afresh by Mr. Spooner on the parabolic principle. They were set off with great care, the extremities being eased off into the reverse curves or straight lines. The result of this is that the train passes from one curve to another imperceptibly, unless one takes note of the cant. The super-elevation on the greatest curves is 3 in.

The permanent way is admirably laid, and as a rule excellently kept up throughout. It is well ballasted and drained. Double-headed rails are used of 49½ lb. to the yard. A good part of the line is laid with steel rails. In the draughting office there are some interesting specimens of old permanent way. Among these is a part of the first rails used on the line in the year 1833. These were 16 lb. fish-bellied rails of oval section, 4 ft. long, and flattened at the ends to fasten in the chairs by means of an iron key. They were superseded by a heel rail which continued in use until the year 1868, when the present 49½ lb. rails were adopted. Mr. Spooner uses all his rails twice, planing the underside in the machine before relaying them, so as to take out the depression caused by the impact of rail on the chair. The rails are joined by a fishplate of Mr. Spooner's design. In this the section is such that the web and lower flange of the rail are both supported, the two plates all but meeting under the center of the rail. It has been found that the additional stiffness gained by this arrangement not only affords very much smoother running, but the nuts have no tendency to slack back, as the constant working of the plates against the rail is avoided. The points and crossings are of the ordinary construction.

The rails now laid on this line are fixed by strong chairs to 9 in. by 4½ in. larch sleepers, 4 ft. 6 in. long, and placed 3 ft. apart from center to center, except at the joints, where the pitch is contracted to 2 ft. At each joint a frame is formed by placing two sleepers as longitudinalals under the cross sleepers, and spiking the latter to them. This arrangement, combined with the use of the stiff form of fishplate we have already described, enables the joints to be rendered very firm and even, an important matter in a narrow gauge line worked at relatively high speeds.

At Port Madoc there are facilities which would enable 200,000 tons of slates being shipped per annum, although we believe 140,000 tons is the most that has ever been shipped in one year. The rise of tide is 18 ft. at ordinary springs, but at times there is as much difference as 21 ft. between high and low water springs.

The introduction by Mr. Spooner of the Fairlie double bogie engine opened up a new era for the Festiniog Railway, and has proved one of the most striking features in its history. The first two locomotives used on the line were built by Messrs. G. England & Co., of Hatcham, in 1863. They had four coupled wheels 3 ft. in diameter. The wheel base was 5 ft. and the cylinders placed outside were 8 in. in diameter by 13 in. stroke. The weight of each in work was about 8 tons. The remaining engines of this class were also supplied by Messrs. England, but were about 3 tons heavier. The working pressure was usually 100 lb. In the year 1869, the double boiler Fairlie engine with double bogie "Little Wonder" was built by Mr. Fairlie, at the Hatcham works, and placed on the line.

In 1873, the "James Spooner," also a double boiler double bogie Fairlie engine, was placed on the line. The following are the chief particulars of this locomotive:

DETAILS OF THE LOCOMOTIVE "JAMES SPOONER."

Cylinders:	ft.	in.
Diameter.....	0	8½
Stroke.....	1	2
Distance apart from center to center.....	3	1
Centers of valve spindles.....	0	9
Center cylinder to valve face.....	1	0
Length of steam ports.....	0	6¾
Width.....	0	0¾
" exhaust ports.....	0	1¼
" bars.....	0	0¾
Thickness of piston.....	0	1¾
Number of rings.....	2	
Diameter of piston rod.....	0	1½

Working Gear:

Length of connecting rods between centers.....	4	6
Diameter of crank-pin bearing.....	0	2½
Length.....	0	2½
Diameter of coupling-rod pins.....	0	2½
Length.....	0	2
" of crosshead blocks.....	0	8
Width of motion bars.....	0	2¼
Thickness of motion bars at center.....	0	1¼
Length of eccentric rods.....	3	3½
Diameter of eccentric sheaves.....	0	9½
Width.....	0	2
Throw.....	0	2¼

Wheels and Axles:

Diameter of wheels.....	3	4
Width of tires.....	0	4
Distance between tires.....	1	9
Wheel base of each bogie.....	4	6
Total wheel base.....	18	8
From leading axle to center of bogie pin.....	2	5
" driving.....	2	1
Diameter of driving axles at center.....	0	4½
" leading.....	0	4
" axle bearings.....	0	3¾
Length of axle bearings.....	0	5½
Centers.....	1	3¾
Diameter of axles at wheel seats.....	0	4

Carrier Frames:

Distance between frames.....	2	10¾
Depth of frame at center.....	0	9¾
Center of bogie pins.....	13	10
Width over footplates.....	6	6

Bogie Frames:

Extreme length.....	9	7½
Depth.....	1	4½
Thickness.....	0	0¾
Distance apart.....	1	6¾
Buffers (Thomson's patent).....		
Height of center buffers from rails.....	1	7

Boiler Shell:

Total length between smokebox tube plates.....	21	6
Length of each barrel.....	7	7
Diameter of each barrel inside smallest plate.....	2	6¼
Thickness of barrel plates.....	0	0¾
" smokebox tubeplate.....	0	0¾
Height of center of boiler from rail.....	4	0½
Length of firebox casing.....	6	4
Width.....	2	7¾
Center of boiler to bottom of casing.....	3	0¾
Thickness of side and crown plates.....	0	0¾
" front plates.....	0	0¾
Diameter of steam domes, outside.....	1	6¾
Height.....	1	9½
Diameter of safety valves.....	0	3

Inside Fireboxes (Copper):

Length at top.....	2	7
" bottom.....	2	8½
Width at top.....	2	0½
" bottom.....	2	1
Height of crown above center of boiler.....	0	6
" " " grate at front.....	3	2½
" " " back.....	3	7

Tubes (Brass):

Number in each barrel.....	102	
Diameter outside.....	0	1½
Length between tubeplates.....	7	10¼
Distance between centers, vertically.....	0	2
" " " horizontally.....	0	3¼

Heating Surface:

Fireboxes.....	sq. ft.	84
Tubes (outside).....		629
Total.....		713
Firegrate area.....		11.2

Smokeboxes and Chimneys:

Diameter of smokeboxes.....	3	3
Length.....	2	8
Diameter of chimneys inside at top.....	0	10
" bottom.....	0	8¾
Height of top of chimney from rail.....	7	9
Diameter of blast nozzles.....	0	1¾

Tanks:

Length.....	8	0
Width.....	1	4½
Depth.....	2	3½
Capacity.....	720	gallons.
Weight of engine empty.....	14	tons 5 cwt.
" roadworthy.....	20	tons 1 cwt.

A third class of locomotive was tried in 1876. This consisted of the "Taliesin," a single boiler double bogie Fairlie engine of the following dimensions:

DETAILS OF THE LOCOMOTIVE "TALIESIN."

Diameter of cylinders.....	ft. in.	0	9
Stroke.....		0	14
Diameter of wheel.....		2	8
Wheel base of steam bogie.....		4	6
" trailing bogie.....		3	6
Diameter of wheels of trailing bogie.....		1	7
Centers of bogies.....		9	9
Total wheel base.....		13	11
Heating surface: Firebox.....	29.5	sq. ft.	
Tubes.....	313		
Total.....	342.5		
Firegrate area.....	6.25	sq. ft.	
Capacity tanks.....	380	gals.	
Weight empty.....	12	tons 5 cwt.	
" roadworthy.....	15	tons.	

The bogie composite carriage accommodates first, second, and third class passengers; it has seven compartments and will seat fifty persons, and has been in use since the year 1873. The weight is carried very low down, which is necessary with the narrow gauge; on this account, too, no platforms are required on the line.

The double bogie truck is designed principally for carrying ballast, used in repairing the permanent way. The weight of this is 4½ tons, and it will take 12 tons of ballast, 7 tons of coal, or 3 tons of corn in sacks. By the addition of rising boards, however, over 10 tons of coal have been frequently taken in these trucks. The ordinary 5-ton coal wagon is also shown.

The older stock of the company consists of first, second, and third class passenger coaches. Some of the first class carriages are open, having longitudinal seats placed back to back. Strong leather aprons are provided, and in fine weather these seats are in great demand. The first-class carriages are 10 ft. long and 6 ft. 3 in. wide; the others are 9 ft. 9 in. long and 4 ft. 10½ in. wide, with elliptical springs. The overhang of the passenger carriages with cross seats is 1 ft. 5 in. from center of rail, and 10 in. from the end of the axle.

Passenger carriages with longitudinal seats, which will carry twelve first, fourteen second, and fourteen third class passengers, weigh 1 ton 6 cwt. With cross seats a twelve-passenger carriage weighs 1 ton 3 cwt. Coal trucks and slate wagons to carry 3 tons weigh 19 cwt., and goods trucks for 18 cwt., 2½ tons each. A 2-ton slate wagon weighs 13 cwt. The wheels on these are 1 ft. 6 in. in diameter, and are made of cast iron with Lowmoor tires; those on the slate trucks run from seven to nine years without requiring to be turned afresh. In the office we saw one veteran that had been twenty-six years in wear. The wheel base of some of the rolling stock is as follows, viz.: Passenger carriages, 5 ft. and 5 ft. 6 in.; goods and coal trucks, 5 ft. 6 in. and 6 ft.; slate wagons, 2 ft. 11 in., 3 ft. 1 in., and 4 ft. 1.; slab trucks, 5 ft. The journals are 3½ in. to 4½ in.

About a mile from the Port Madoc station are the carriage and locomotive shops of the company. Everything is naturally in miniature, the wheel lathe especially striking one as being very small. It is this feature that adds not a little to the economy with which this line has been run, and is one of the strong points of the narrow gauge system.

At the locomotive shops the company build their own engines.

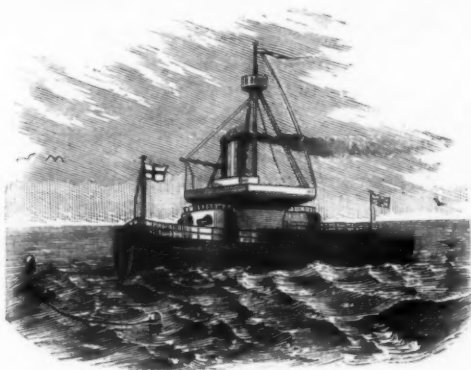
LINKED SHELLS.

ADMIRAL THE HON. ARTHUR A. COCHRANE has devised a novel method of marine attack and defense which deserves some attention, says *The Engineer*. Its very novelty may tend to prejudice against it those who are saturated with the conviction that nothing new which is also good can be devised in warfare; but the whole scheme is at once so simple, so ingenious, and so easily and cheaply tested, that it commends itself to impartial minds.

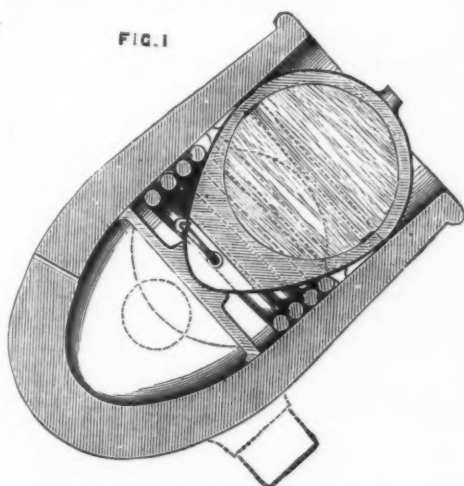
It is well known that if war were to break out our mercantile marine would be, to a large extent, at the mercy of our enemies; and various proposals have been brought forward for fitting our large passenger steamers with guns which would enable them to beat off a foe. So many difficulties stand in the way of adapting a steamer to carry even one heavy gun, that very few vessels are on the admiralty list as suitable for carrying guns. Admiral Cochrane's proposals are intended to get over these difficulties, and render any ship which can carry a couple of light mortars comparatively safe from an enemy.

In few words, he proposes to strew the line of approach of a hostile ironclad preparing to ram, or the wake of a

ship when retreating, or the course of an enemy engaging on the broad-side, with floating or partially submerged torpedoes, through which the pursuer dare not attempt to pass. These torpedoes could be thrown to some distance from the ship by means of mortars, which would fire very small charges of powder. Thus the 13 in. service mortar, at an elevation of 45 deg., has a range of 850 yards, with 3 lb. of powder, and with half a pound of powder a range of 180 yards when projecting a shell of about 180 lb. weight. The shells would have a charge of high-class explosive, say, of 35 lb. weight, surrounded by an envelope, whether of thin metal or other material, of sufficient capacity to buoy the bursting charge, and of strength to resist the projecting charge of, say, 1½ lb. of powder. The shells



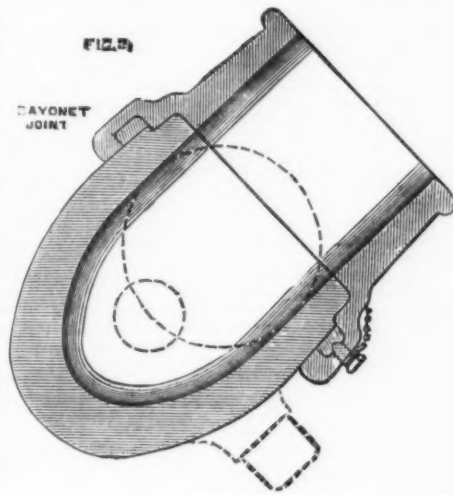
would be connected by a floating line 100 ft. or 200 ft. in length, of small diameter, but of great strength; such coupled shells could be fired from two mortars simultaneously by electricity; they could be placed close together, or the mortars, of which there might be six or eight on a large ship's deck, might be placed at a distance apart of 50 ft. or 80 ft. on the line of keel or otherwise, the rope still connecting the shells. The action of the air on the connecting line when the shells were fired would be to draw the shells together; but it is not anticipated that this would be a practical difficulty over the ranges expected, viz., from 200 to 1,200 yards, as the mortars would be slightly deflected from each other. It is proposed to use such shells against ships on their near approach by firing them across and just ahead of their ship. It is clear that if the hostile ship still proceeded, like the ironclad in our sketch above, she would, by fouling the rope, draw the shells alongside and be blown up; and as the shells would be concussive and fitted with time fuses, they would doubtless not fail to act. Should the ship stop in time to avoid the shells, others could be thrown astern of or over her, so as to hamper her movements. Under any circumstances, the hostile ship could not ram her enemy, and by stopping would offer a good target for mortar shells to be thrown on her decks, and for artillery fire. Admiral Cochrane suggests that the shells proposed could be fired without a connecting rope and of a gravity slightly greater than water, so as by firing them ahead of or near to a ship, they would, on falling in the water, very slowly sink, so as to give time for the ship, if she pursued her course, to pass over them, when they would explode by impact or by time fuse, thus in all probability destroying the ship. Under any circumstances, if the enemy altered her course suddenly to avoid the shells floating or submerged, it would altogether prevent the intended ramming taking effect. Such shells might also be fired to disable approaching torpedoes, and to destroy or interfere with the progress of torpedo boats. Such linked shells made on a large scale could be drifted up with the tide to destroy ships lying in a harbor.



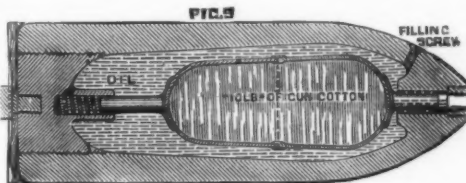
It is proposed to employ shells of several classes: "A" shells, charged with explosive, capable of floating on water, cased in metal or other material, and united by a floating rope; to be fired across the bows of ships, or dropped across ships or forts in a tideway. "B" shells, charged with explosive of slightly greater specific gravity than water; such to be regulated as to the depth they shall sink in water by means of an India-rubber tube or other material; such tube to be attached to the shell when fired, or by a line to the shell when necessary, filled with air and attached to the shell. In the case of land service, such tube could be filled with explosive, and such tube could be attached to a second shell, for clearing parapets, trenches, etc., under special circumstances. "A" shells would be useful to clear hostile ships out of rivers, tideways, and to blow up the buttresses of bridges, floating bridges, such as those lately used in the Danube, for preventing ships entering the Dardanelles, etc. "B" shells, on being thrown near ships and buoyed, by a practically invisible tube, at a depth of, say, 15 ft., would be very fatal on exploding. "B" shells could be thrown on the line of advance of a torpedo; and when entering a hos-

tile port, defended by submerged torpedoes, they could be thrown in advance of ships entering, and regulated, by means of the buoy line, to explode at any depth, or on the bottom, thus clearing the channel. The shells could be cased in metal and made in sections, or could be made of paper suitably prepared. Shells from mortars are now considered to be efficient in proportion to their falling weight. The shells suggested would be efficient in proportion, not to their weight, but to the charge of explosive carried. From the small weight of the mortars, small charge, and small recoil, they could be fitted to any ship almost without strengthening fittings, and in the case of river steamers would add but little to the draught of water.

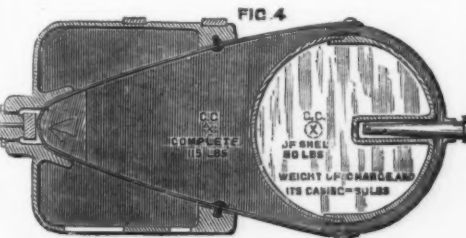
It will be seen that the success or failure of the whole



scheme depends on the possibility of firing linked shells, so that their line of flight would be nearly parallel; and on the construction of the shells. Nothing but direct experiment can decide the first point; but it might be settled in a day for an outlay of a few pounds. The construction of the shells obviously presents some difficulties. Admiral Cochrane has proposed several designs for shells, intended to overcome these difficulties. Fig. 1 shows a common mortar, with the shell and a portion of the buoying tube in it, as also a metal plate or gas check, to receive the shock of the charge, etc. Fig. 2 shows a jointed mortar, made of phosphor bronze, for use in case a single casting of the required dimensions should be thought too heavy. The extension ring is secured to the base by a bayonet joint. Fig. 3 shows a 10 in. steel rifled shell for firing from a gun or howitzer. Fig. 4 shows a shell intended to float, with its fuse tube and a gun-cotton charge. It is a modified form of Fig. 1. In general configuration it resembles the shape of the large shells used in fireworks, these weighing some 40 lb., and perhaps 13 in. in diameter. The metal case inclosing the rear of the shell is another form of gas check, the sides of which are prolonged so as to transfer the first shock of discharge more uniformly over the surface of the shell. On the rear of the case being well clear of the gun, it is supposed to be blown away from the shell by a small bursting charge, but on the whole Admiral Cochrane does not attach much consequence to the design. In Fig. 3 a small connect-



ing tube is not shown as connecting the oil chamber under rear plunger with the oil between the inner and outer shells. Some persons may be of opinion that fire from mortars, whose shells would be, or might be, connected by a slight line, would be very inaccurate, particularly in high and cross winds. But if one is driven to make comparison of efficiency, the accuracy of artillery fire in ships in high cross winds may be seriously questioned, and the accuracy of action and aim of torpedoes fired from or at ships in motion may be very much more seriously questioned, particularly if fired at more than 500 yards distance. An order that under-water fittings for firing torpedoes from the broadside were to be discontinued has recently been published, it being found impossible to eject them satisfactorily at speed. The bows and sterns of ships are now the favored points for projecting the torpedoes, and compressed air, steam, steam pistons, and now gunpowder are being tried



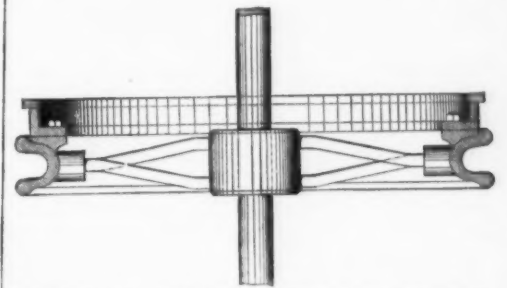
to endeavor to obtain a satisfactory means of projecting them into the water, after which they have to find some yet undiscovered process of making them go straight to the object to be struck, a result which, when there is any sea on, or the boat or vessel any way on, will never be accomplished in any degree to be relied on. A comparison may be made between the effect of fire of, say, 100 ton gun, 30 ft. long, burning 400 or 500 lb. of powder, and projecting shot of, say, three-quarters of a ton, against a 26 in. armor-plate,

the result when a hit is made being, so to say, trivial compared to the effect of one of the shells proposed by Admiral Cochrane falling, when charged with 20 lb. or 30 lb. of gun cotton, on the deck or into the barbettes battery of a 10,000 ton ironclad. Further, when the cost of the 100-ton gun, the powder, and shot fittings, and complication of hydraulic gear required to work such a gun are considered, as against a 13 in. mortar, weighing perhaps 12 cwt., and requiring, so to say, no science to work it whatever, the advantage seems not at all in favor of mortars as the principal arm.

It may be observed that a sea service 13 in. mortar weighs about 5 tons; its shell, loaded, about 200 lb., carrying a bursting charge of some 10 lb., and when fired at an angle of 45 deg., with 3 lb. of powder, ranges 850 yards; but as at present Admiral Cochrane only suggests shells of a weight of, say, 100 lb., and that to be projected to a distance of, say, 1,200 yards, and that as the mortars should be made of phosphor bronze, 12 cwt. might, it is assumed, suffice for the weight of the mortar. The S.S. mortars have to face the firing of 200 lb. shells up to a range of 4,000 or 5,000 yards. Mortar firing and sustained efforts to improve mortars have been but little considered. Rifled mortars are hardly known; and the suspended mortars—Robert's patent—on turntables for sea service—used in the Baltic in 1854—have dropped out of sight, though they were stated to offer many advantages in principle, though faulty metal and construction were quoted against them.

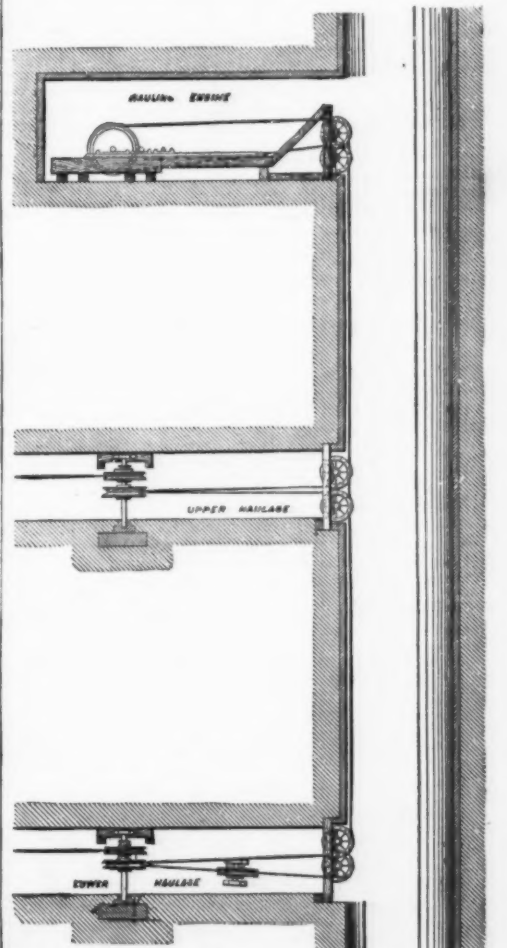
UNDERGROUND HAULAGE.

MESSRS. JOHN WOOD & Co., Water Hayes, Wigan, have designed an excellent and ingenious arrangement of haulage



SECTION OF DRIVING PULLEY FOR ENDLESS ROPE HAULAGE.

for a large colliery. The hauling engines are fixed, not on the surface, but at a mouthing off the shaft, at which place there were steam boilers. From here the hauling rope passes down the shaft, calls at intermediate seam, and passes



ENDLESS ROPE HAULAGE ARRANGEMENT.

ing round a pulley transmits power to an endless rope, then to the bottom of the mine, and works a number of branches.—Colliery Guardian.

It is stated that pressed glass is turned out in the Siemens works that is as hard and tough as cast iron. It is far lighter and not affected by temperature, etc. It is intended to make out of this hard crystal, street lamp posts, stairs and gas and water pipes. It is thought these articles can be made 30 per cent. cheaper than in cast iron, but will not, of course, be so heavy.

YAGN'S PARACHUTE HYDRAULIC MOTOR.

WITHOUT entering into common places in regard to the immense motive power of rivers, which we leave almost totally unused, it will yet be permitted us to state our astonishment at the insufficiency of the means hitherto employed for obtaining at least a small portion of such power. If, in fact, we except a few cases, like the falls of the Rhone at Bellegarde, or installations like that of Marly, which can only be effected by damming, the motive power of rivers is scarcely utilized except through floating wheels. Even these lat-

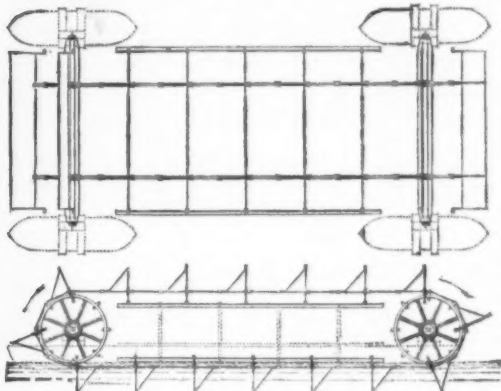


FIG. 2.—PLAN AND ELEVATION.

ter are not much employed, and we shall see that there is nothing surprising in the fact that they are not. Let us see, in fact, what Colladon's pendent wheel can do when established under the best of conditions. The wheel may be theoretically reduced to a paddle that would move in the direction of the current with the tangential velocity of its center of gravity. Let V be the velocity of the current; v that of the center of the paddles; and M the mass of water that impinges against the latter per second. We shall have $M = \frac{1,000}{g} S V$, S being the immersed surface of the paddles. The theorem of the quantities of motion applied to the mass

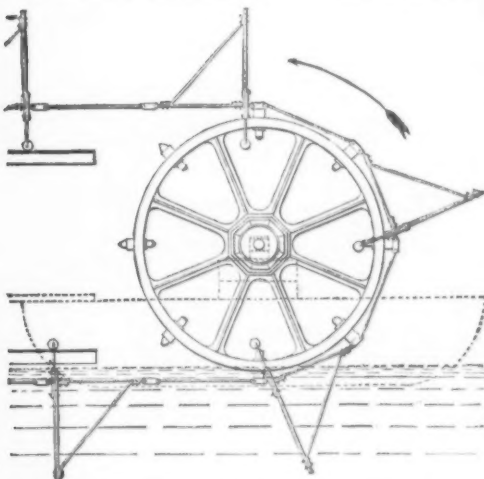


FIG. 3.—DETAILS OF WHEEL AND CHAIN.

of water that passes from a velocity V to a velocity v (projected upon the direction of the current) will give the stress exerted upon the paddle; whence the work (T) obtained. We thus find

$$T = \frac{1,000}{g} S V (V - v).$$

The maximum corresponding to $v = \frac{V}{2}$ will be

$$T = \frac{1,000}{g} S \frac{V^2}{4} \text{ (in kilogrammes).}$$

The value of T changes but little for quite great variations of v in the vicinity of $\frac{V}{2}$. The experimental authentication

that the maximum occurs for $v = 0.4 V$ seems even to invalidate this formula. We have, in fact, applied a calculation of the shock of soft bodies, something which is in no wise the case. Yet experiment has proved that this formula may be adopted by applying thereto a coefficient of reduction of 0.80. The practical formula, then, is

$$T = 0.80 \frac{1,000}{g} S \frac{V^2}{4} \text{ or, in horses,}$$

$$T = 0.80 \frac{1,000}{g} S \frac{V^2}{4} \times \frac{1}{75}$$

In a current of 1.5 m., the surface of the paddles being four square meters, we would be able to obtain 3.6 horse power. This, from its large dimensions, would prove a costly apparatus for a little power. The other machines employed are still more inferior.

However, we cannot increase the dimensions of the wheel to an immeasurable degree, as we should have to do if the current were not very rapid and we desired a greater power. The vice of the system that leads to such dimensions is that only an insignificant fall is utilized. At a very short distance down stream the water again takes on its former velocity, not only under the action of the incline, but also under that of the neighboring masses of water. It is necessary, then, to cause the current to operate over a greater extent in order to obtain more work from it. This simple idea was carried out in a satisfactory manner more than twenty years ago, in Mr. Roman's pendent hydraulic chain. Zschische's hydraulic motor is merely an imperfect reproduction of Roman's.

As the reasons that caused the failure of Mr. Roman's enterprise were, as far as we know, not of a technical nature, and as the apparatus, under many circumstances, permitted of the utilization of considerable power with very little cost of keeping in repair, we believe that the idea may be usefully revived. This is why, before speaking of a very recent invention, we shall, in a few words, recall what Roman's chain was. The apparatus consisted of two endless chains formed of long links connected with each other by means of hinge bolts, through couples of short links. These latter, through the eye left between them, engaged with points upon the supporting wheels. The two front supporting wheels were keyed upon the driving shaft. The long links carried paddles that were kept stationary and perpendicular to the chains by a system of braces placed behind them. These paddles, which firmly connected the two chains placed parallel with the current, were always at right angles thereto. They were, moreover, supported in their horizontal travel by a skillfully distributed system of guides and rollers.

Mr. Roman had remarked that when one exposes to the current one paddle, then two, three, etc., equally spaced, the stress, measured by counterpoises or the dynamometer, increases in arithmetical proportion. The stress exerted upon each of his paddles, which were 5 m. in width with a depth of 48 and 66 cm., was 0.75 of the pressure exerted upon the first one, with a spacing of 1.5 m. As the first is in the same condition as the paddles of the pendent wheel, the work furnished by the apparatus should be

$$T = 0.80 \frac{1,000}{g} S \frac{V^2}{4} (1 + 0.75 (n - 1))$$

in kilogrammes, n being the number of paddles immersed.

Upon comparing the results given by the application of this formula with a table of experiments extracted from a report by Mr. Cambresy, we find the following facts: The velocities of the current being 1.013 m., 0.942 m., and 0.47 m., the work, measured by the Prony brake, was 97 per cent., 80 per cent., and 60 per cent. of that given by the above mentioned formula. We may deduce from this that the formula would be exact with velocities of more than one meter. It was to be foreseen that, as the power of the apparatus rapidly decreases with the velocity of the current, friction would absorb a greater and greater part of the total work. The two first data have reference to an apparatus of 15 paddles, of which seven were immersed, and 4.95 m. \times 0.475 m. in dimensions, and the third to a machine of 70 paddles, 34 of them immersed and 5 m. \times 0.66 in dimensions. Unfortunately, the velocity of the current did not exceed 0.47 m. during the entire time of the installation. It may be seen that in many cases (those in which the velocity is sufficient) this apparatus might furnish a power of several hundred horses at a slight cost for the first establishment, and a minimum expense for maintenance.

Yagn's Hydromotor.—The parachute hydromotor that we shall now describe rests upon this same principle of utilizing a greater extent of the current; but its construction is very different, and its effective performance, as well as the limits of its power, makes it absolutely different from the hydraulic chain.

The apparatus (Figs. 6, 7, 8, and 9) consists essentially of two endless cables of hemp or bast, which pass over a wooden drum carried between two boats. These cables are provided with sail-cloth parachutes which open during the descent and close up upon ascending. These parachutes,

which may be seen in detail in Figs. 6 and 9, are held by six cords, which, surrounding them like a net, prevent them from turning wrong side out. These cords have likewise the effect of strengthening the cloth, and of thus permitting it to withstand very strong pressures. The space between the parachutes is equal to twice their diameter.

Upon leaving the drum, the parachutes at once open, and operate as far as to the extremity of their descending travel. Reaching this point, they run over the return pulleys, B (shown in detail in Fig. 4), which are placed in a wooden frame, kept

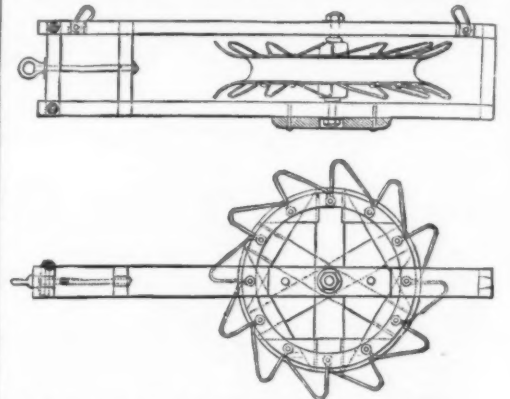


FIG. 4.—RETURN PULLEY OF YAGN'S HYDROMOTOR.

in position by a float and weights. These pulleys have a very deep channel, which is formed by bent metallic bars (galvanized iron, copper, or brass). This arrangement facilitates the rolling of the parachutes, and submits them to as little friction as possible, this being an important matter as regards the work absorbed by flexion. Guide pulleys, A (Figs. 5, 7, and 8), arranged in an analogous manner, but with an anchorage in addition, guide the ascending cable to the drum.

The parachutes, upon ascending the current, are completely flattened upon the cable, not only through the thrust of the current, but also by the suction of the water that they contain, due to their motion. The experiments upon the Neva, at St. Petersburg, where the apparatus was operated last summer, showed that the folding of the cloth was effected with force and regularity, and that the resistance

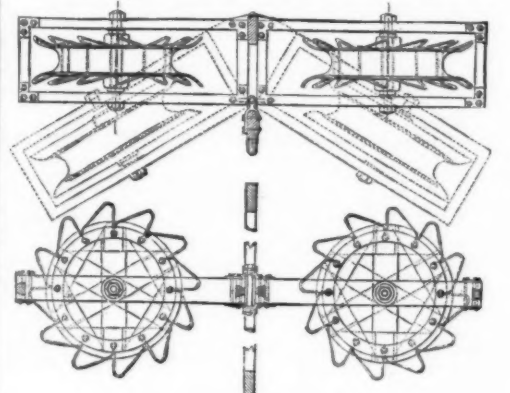


FIG. 5.—GUIDE PULLEYS.

to the ascent was scarcely more than 0.01 of the stress at the descent.

In order to maintain the tension of the cables, and to keep them from separating and becoming slack, the frames of the pulleys, B, carry at the rear a piece of cable provided with several parachutes and ending in an oblique board, C (Figs. 7 and 8).

The drum, T, is mounted between the two boats in the wooden frame that connects them. It is all of wood, save the two cog-wheels that serve for transmission. The cylindrical portion is formed of planks provided with two grooves in which the pulleys, R, guide the cable. The two ends and a central disk are formed of three thicknesses of planks, crossed at an angle of 60°, which rest upon three key beds upon the iron axle of the drum.

In order to obtain sufficient adherence, in avoiding numerous windings that would strain the cable and absorb power, Mr. Yagn places at the entrance of the cable upon the drum two compressing rollers, P, that act by weights or springs. These rollers, which are covered with hemp or leather, do not injure the cable, and even slightly diminish its wear by flattening the fiber. The felly could not be of naked iron, for it is absolutely necessary to prevent the cable from running over rust.

The experiments made last year upon the Neva, and in the months of March and April of this year at Lyons, demonstrated that the action of the current upon the end parachutes was perceptibly the same as upon the first one, provided their spacing was four times their diameter. The same result may be reached with a spacing of two diameters if the cables be inclined about 10° with respect to the current; hence the arrangement described above for having such inclination.

The cables provided with parachutes have a specific weight of very little more than unity, and are kept floating by the simple action of the current upon their curve. It has been found possible to give them a length of as much as 400 or 500 meters from the drum to the return pulleys. The practical dimensions are included between 0.60 m. and 2 m. in diameter, say from 0.28 sq. m. to 3.14 sq. m.

The experiments upon the Neva gave as the value of the work in horse power collected by the drum

$$T = 0.2975 S V^2,$$

where S is the total surface of the parachutes, and T the velocity of the currents. The more recent experiments at Lyons gave, it appears,

$$T = 0.32 S V^2.$$

This difference must be due to the fact that in the first ex-

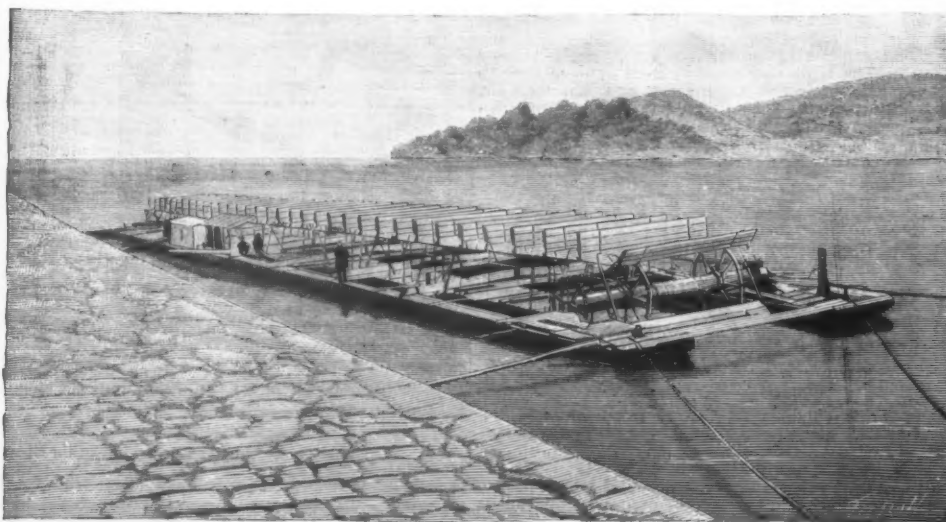


FIG. 1.—ROMAN'S PENDENT HYDRAULIC CHAIN.

periments the receiver was a system of two coupled drums (called Betancourt drums) with a multiple winding of the cable.

The theoretical formula given at the beginning of this article would be reduced to

$$T=0.34 SV^2.$$

Thus showing that the form of the parachutes is very appropriate for receiving the action of the current. There is, moreover, one thing that perceptibly differs from the theory, and that is that the most advantageous velocity, v , of the cable was always $v=\frac{1}{2}V$.

Let us point out a few special advantages:

The cable can work under ice; the wind and waves do not influence it; and owing to its flexibility and the possibility of immersing it to any depth, it does not interfere with navigation, and occupies upon the river only the place of the boats. Moreover, in an hour, all the floating parts may be gathered up and anchor be weighed, in order to carry the motive power to some other part of the river.

The first cost is small; but in cases where such a condition has a special importance, the apparatus might be utilized upon an unnavigable river, where other and more perfect motors (such as undershot or turbine wheels) would be possible. One could then employ but one cable, place the drum upon the bank, and cause the cable to follow the sinuities of the stream by means of guide pulleys. The only costly thing about the apparatus is the renewing of the cables and parachutes. We shall soon have further data in regard to the apparatus, for Mr. Yagn has treated with Messrs. Gabert Bros., at Lyons, for the exploitation of the

basin of the Rhone. Two apparatus are being constructed, one of which is to operate at Lyons, and the other near Avignon for irrigating purposes. On another hand, a hydromotor mill has just been mounted upon the Neva, near St. Petersburg, and two other hydromotors are being constructed, one for Dresden and the other for Vienna.—*La Génie Civil*.

TRAINING IN NAVAL ARCHITECTURE.

At Govan, the great shipbuilding suburb of Glasgow, on the 4th Sept., Prof. F. Elgar, of Glasgow University, addressed the students attending the Science and Art Classes upon the above subject. In the course of his address Prof. Elgar said:

"All of the students who attend the classes in naval architecture and engineering here are probably much better acquainted with the practical and experimental aspects of the work they are engaged in than they are with the science which underlies it; and their present object is the very vital and praiseworthy one of acquiring such scientific and technical knowledge as will enable them to apply sound principles to the performance of their work, and to assist them in dealing intelligently and successfully with the many difficult and novel questions which are constantly obstructing and puzzling them. There are no branches of mechanical art in which sound scientific knowledge is more essential and useful, or in which it is more necessary for theory and practice to go hand in hand together, than those of shipbuilding and engineering. A modern steamer is so complex a machine that no attempts to construct one without calling in

the aid of science in some form—either directly or by copying what others have learned by it to do—could possibly end in anything but disastrous failure. Try to imagine a man who had never heard or read of any of the teachings of science attempting to construct a modern steamship—a man who did not know even of the proposition, said to have been demonstrated by Archimedes, that a floating body displaces a volume of water whose weight is equal to its own weight—and who was ignorant of the wonderful discoveries that have been made of the laws by which heat generated by the combustion of coal is converted into mechanical work through the agencies of the boiler and steam-engine. It only requires to state the matter in this bold form in order to show how hopelessly impossible and absurd such an attempt would be, and how vitally dependent shipbuilding and engineering are upon the past achievements and present teachings of science. On the other hand, the highest scientific talent the world has yet produced would be equally unable to arrive at a successful result simply by means of pure theory, however advanced, and by strict *a priori* methods. The course you are pursuing, and which I trust you will not depart from, is the one best best calculated to insure for you the greatest success in your work and advancement in your various positions in life; and as in the daily practice of your profession you are perforce kept well abreast of the practical and experimental sides of your work, I would now urge you, in the strongest manner possible, to cultivate most diligently and thoroughly a knowledge of the science and of those natural laws upon which the efficiency and success of your efforts depend. Whatever may be the character of your daily work, whether you are employed as engineers, draughtsmen, or mechanics—and I am very pleased to know that there are working mechanics who attend these classes, and who are among the most earnest, intelligent, and capable of the students—never rest satisfied till you know the meaning of all that you do and why you do it. Do not be content with merely learning methods of setting off work and performing calculations, or with copying processes you may may have seen others employ. The man who merely does as he sees others do, without very well comprehending why they do it, and who works strictly by rule and line, looking to custom as the supreme authority, will never improve or advance himself, nor be of much real use in such times as these; nor will he find much interest in his work.

"Custom, which all mankind to slavery brings,
That dull excuse for doing silly things."

Never look to custom as being a sufficient authority for anything, however respectable its antiquity may have made it; but be determined to understand for yourselves whether or not it is based upon sound and intelligible principles. Although we are now meeting under the auspices of the Young Men's Christian Association, I can safely recommend you to indulge freely a spirit of skepticism in this particular department of the Association's work. The region of science and of the pure intellect is not one in which you should be content to accept the mere authority of any one as final, or to test any question except by the standard of your own reason. Do not be too eager to believe that anything you are told is correct until you are able to prove it for yourselves, and till you no longer feel any ignorance or doubt in the matter. The necessity for combining wide scientific knowledge and sound theory with practical experience, in the carrying on of the shipbuilding and engineering operations, is daily becoming more and more pressing. If you tried to avoid it, you could not. In this age of keen competition and rapid development, increasing demands are made upon all who are engaged in these important industries. Every success that is achieved by the most advanced and sensational productions creates a demand for still further progress; and in meeting these demands, in the future, the race will be to the swift and the battle to the strong. The speed and the strength that you require in order to enable you to hold your own in this contest are speed and strength of intellect. In other words, you require your intelligence to be cultivated and well informed, and to be made prompt and active, by means of scientific culture; and it is necessary for you to acquire such a firm and comprehensive grasp of sound theoretical principles as will enable you to rely safely upon your own powers of judgment, and to act in difficult cases with certainty and precision. Not only does modern competition ever demand more from you in the way of technical knowledge, skill, and resource, but it also shortens the time at your disposal for supplying it. The huge and complicated engineering structures of the present day, such as are constructed in this district, have to be completed in as short a time as the much simpler and smaller ones of a generation ago. You have thus not only much more to think about in building a ship, and problems of greater number and difficulty to solve than used to be the case, but you have only the same time in which to do it all. You cannot afford to delay the progress of construction for the purpose of trying experiments or brooding over any difficulties you may meet with. It is necessary to decide promptly each question as it arises, and you have to qualify yourselves for doing that. The naval architect and engineer of the present day requires to supplement his practical knowledge by a close and systematic study of various branches of science. An enumeration of some of the chief of them will be sufficient to show how great are the demands thus made upon him. There are the laws upon which the flotation and stability of ships, and their behavior among waves, depend; those which determine the structural strength of a vessel, and its relation to the forces which may be brought to bear upon her by her own weight and that of her cargo, when she is floating upon a changing wave-surface; the difficult problems connected with the resistance of a ship to motion through the water, the power requisite to drive her at a given speed, and the manner in which this is affected by the outward form and proportions. Then there is the wide field of thermal science, and its application to the means by which the conversion of heat into mechanical work is effected through the agencies of the boilers, cylinders, condenser, and mechanism of the engines; together with the action of the propeller, and the principles upon which its efficiency depends. No man has ever yet succeeded in completely mastering these difficult and complicated problems, and it is perhaps not possible for many of you to advance very far toward their solution. Still it must be borne in mind that it is only by studying the sciences which bear upon them that any real or substantial progress can be effected; and although finality may be unattainable, great advances are possible, and are constantly being made. Hardly a year passes without something considerable being done to improve our knowledge of those natural laws upon which the safety and efficiency of ships at sea depend. There is probably no district in this country which has benefited more in the past than Govan by scientific progress and great me-

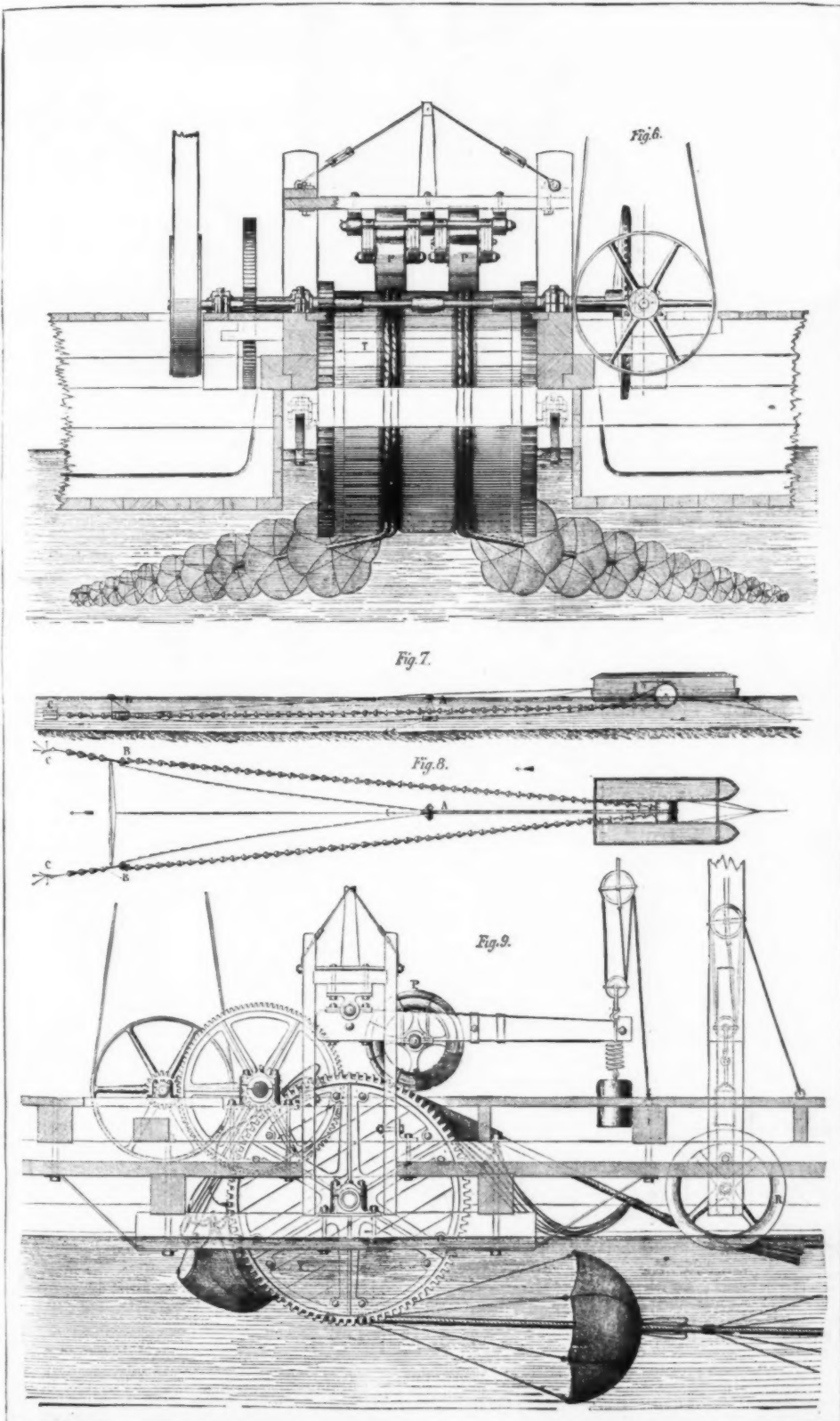


FIG. 6.—Front View of Mechanism. FIG. 7.—Side View of the Apparatus. FIG. 8.—Plan. FIG. 9.—Side View of Mechanism.

YAGN'S HYDROMOTOR.

chanical skill in shipbuilding and engineering, or whose prosperity in the future is more dependent upon it.

Govan has been placed among the foremost of shipbuilding communities by means of great scientific and practical talent, industry, and enterprise; and it rests with many whom I now see before me to maintain it in the honorable and distinguished position to which it has been raised. The names of Napier and Elder, not to mention others, are alone sufficient to give prestige to any engineering locality; and they insure for Govan a high place in all future records of scientific, mechanical, and industrial progress. Upon you rests the responsibility of worthily walking in the footsteps of those and others among your distinguished men, and of striving to keep erect in this district the noble edifice they have reared."

FRIEDRICH & JAFFE'S ENGINE AND BOILER.

THE steam engine built by Messrs Friedrich & Jaffe, of Vienna, and which is represented in Figs. 1 to 6, recom-

wheels; and Figs. 3, 4, and 5 are longitudinal, transverse, and horizontal sections. Fig. 6 shows the condenser and purifier in section.

The generator consists of a steel and forged iron box, A, containing tubes, C, and provided with a cover, b, which is easily removed for cleaning them. The steam cylinder, B, is placed in the dome, D, so that the steam contained therein is always dry. The dome is surmounted by a frame, E, which supports the shaft, F, the bearings, the regulator, G, the distributing valve, a, the eccentric, g, and the pump chamber, h.

The utilized steam which escapes from the cylinder, B, goes to the condenser, K. The water of condensation, after traversing a purifier, N, flows toward the feed pump, A.

The condenser, K, consists of a vessel, O, into which cold water is passed, of a cover, Q, and of several small vertical tubes, r. The lower reservoir and cover are firmly affixed to the vessel, O, by means of bolts, s, s₁, s₂, and s₃. The steam, making its exit from the cylinder, B, rises through the tube, R, and redescends through the tubes, r, in which it con-

that separates rises into the purifier, from whence it is drawn off from time to time through the cock, x.

In the circular motion of the water in the generator, there occur losses that are compensated for by the cooling water introduced into the condenser, k, and which is made to flow through the cock, y. The fire is regulated by means of a damper, w, which allows the air to pass automatically over the grate, through the conduit, n, when the tension of the steam in the generator becomes too great. This damper is maneuvered by a rod, l, which acts upon a counterbalanced lever, o.

The hopper, L, is filled with fuel every two hours. The fuel becomes highly heated by its proximity to the furnace. There is thus produced a distillation through which the combustion is so complete that there is no escape of smoke through the chimney. This latter may be very small, since it has no other role than that of allowing the incombustible gases to escape. The boiler possesses a wide heating surface, and all its parts are easily accessible. Owing to such facility in cleaning, the motor is capable of running just as well

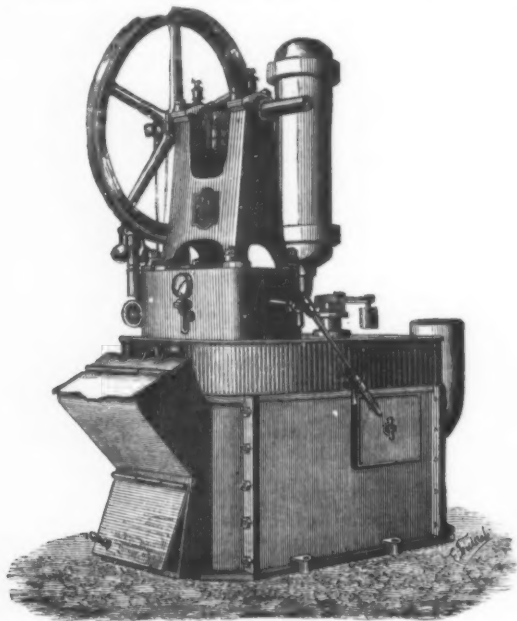


FIG. 1.

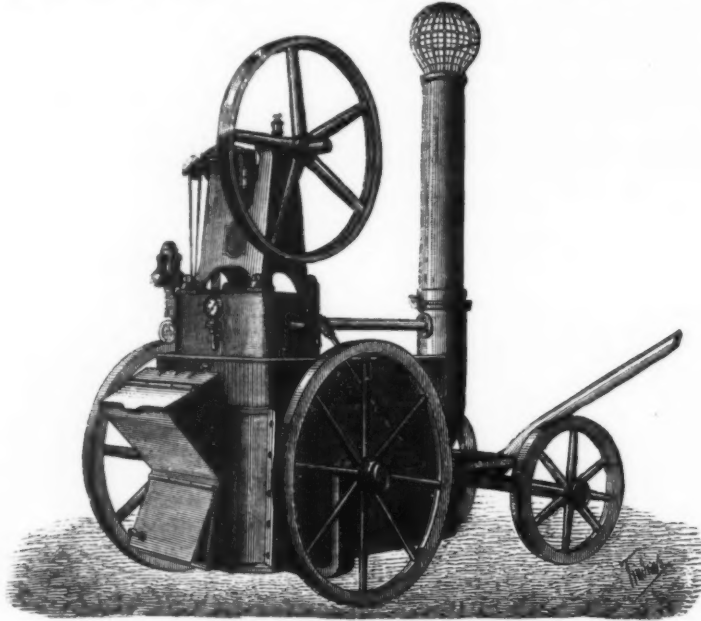


FIG. 2.

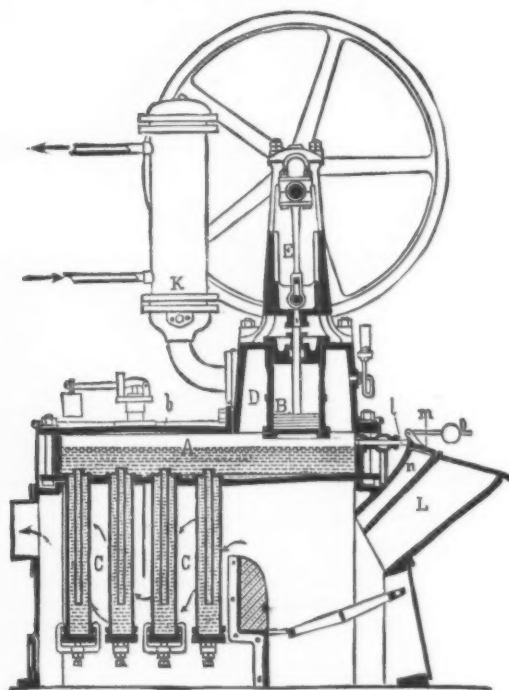


FIG. 3.

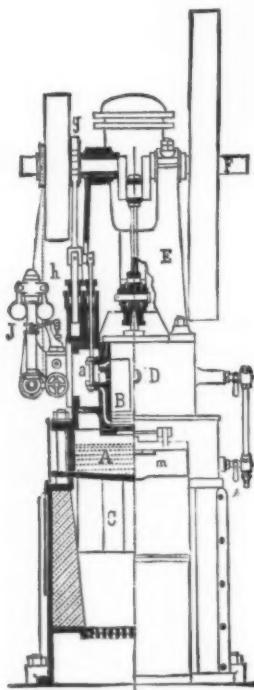


FIG. 4.

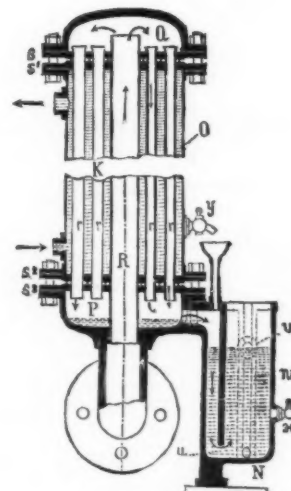


FIG. 6.

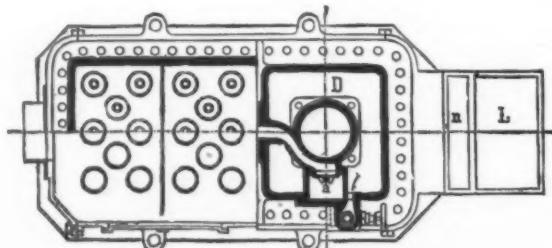


FIG. 5.

FRIEDRICH & JAFFE'S STEAM ENGINE AND GENERATOR.

mends itself to the attention of users of this class of apparatus by the regularity of its running, the simplicity of its mechanism, and the ease with which its parts may be examined. These different qualities concur to reduce the cost of cleaning and keeping in repairs to a minimum, and make an excellent motor of it for the smaller industries.

Fig. 1 gives a general view of a 4 horse power stationary engine; Fig. 2 gives a view of the same mounted upon

densens, owing to the cold water that circulates around them. The water which is derived therefrom collects in the reservoir, P, and from thence passes into the purifier, N. This latter is a vessel into which the water of condensation enters at the bottom, rises into a lateral conduit, w, and, reaching a certain height at v, empties into the reservoir of the feed pump. The water, which enters contaminated with oil, gives up the latter at the orifice of the conduit, w. The oil

without as with condensation. The advantages of this motor, as regards ease of access, small consumption, and proper utilization of heat, are such that we doubt not that it will soon come into general use in the smaller industries. At the Vienna Exhibition, this motor, running at a pressure of from four to five atmospheres, actuated an electric machine that furnished a remarkably regular current to forty-two 16-candle incandescent lamps.—*Le Mouvement Industriel*.

DEEP CENTER-BOARD CATAMARAN.

To the Editor of the Scientific American:

I am an old Jack tar, although now farming, but I like sometimes to have a trip on my sailing boat. I think it was in 1879 I first saw the engraving of a double boat in the S. A., and arranged one for myself, and began to have a race with the steamboats on the river; with a good breeze I beat them all but one fast-running devil. Thinking what to do—impossible to enlarge the sails, they were already too large, sometimes driving the double boat. Well, I put a keel between the two boats twice as deep as the depth of the boat, put the rudder on the middle keel, enlarged the sails, and since then I have always beaten the fast running-devil, having sometimes a speed, half wind, of 14 miles, with a strong breeze on smooth water. The arrangement is easily seen from the engraving. There is no patent on this invention, but I am sure the Yankees will try it, and surely they will beat all the yachts in the world.

A subscriber to your valuable paper.*

ALRIK PALMGREN.

Mouroume, on the Oka River, Russia, Sept., 1884.

CAUSES OF BOILER EXPLOSIONS, AND THE PREVAILING ERRONEOUS OPINIONS REGARDING THEM.*

In presenting my views on the subject of boiler explosions, I do so with some degree of diffidence, believing that very few, if any, in this community agree with me, and knowing by experience that he who steps out of the beaten path will ultimately find a hard road to travel.

It is the almost universal opinion that no boiler properly filled with water will explode. My opinion is that a boiler filled with water will not only explode, but the more water in it the greater will be the destruction to life and property.

The purport of this paper is not only to impress on the attention of those having charge of steam boilers constant watchfulness in keeping a proper supply of water in them, but care in all matters that tend to depreciate their strength and safety, especially the danger of carrying a higher pressure than the boilers will sustain. Also to dispel, if possible, the common and baneful delusion that a boiler filled with

sphere? If it escapes, how does it go off? Does it flash into steam instantly, or go off slowly by radiation? If the facts are that the water in a boiler working under a pressure of 147.3 pounds, suddenly relieved from 133 pounds pressure, instantly flashes into steam, what will be the proportional increase of volume between the water and steam when relieved suddenly from pressure?

It is accepted as a rule that one cubic inch of water converted into steam, under one atmosphere, increases its volume 1,696 times. The pressure in the boiler being 147.3, and that of one atmosphere 14.73, the steam will, when relieved from pressure, expand or increase its volume ten times as compared with 1,696 of the water, or the volume of the water increasing 169.6 times in proportion to one of steam.

Now if the before mentioned rules governing the generating of steam have been correctly stated, and the conclusion legitimate, it will be conceded that the water, when heated over 212 degrees of heat, becomes explosive when relieved from pressure in proportion as its temperature is greater than 212; therefore, in proportion as the volume of water is increased will the explosion be greater.

Mr. Donny, an eminent scientist, supports the conclusion that superheated water—that is, water heated over 212 degrees—will explode. He states that, in an experiment, he heated water in a glass vessel to 300 degrees, when the water instantly flashed into steam and broke the glass vessel into fragments.

Doctor Papin, a French scientist, states that he heated water to 400 degrees in a digester.

Zell's Encyclopedia states that the temperature of water cannot be raised over 212 degrees under a pressure of one atmosphere, but that the temperature can be raised to any degree dependent on the strength of the vessel to sustain the pressure.

Gay-Lussac, another scientist, states that his experiments demonstrated that superheating steam separate from the water increased its volume or pressure but little.

Mr. Hasseler, another authority, demonstrated that water at 38.5 degrees temperature was at its maximum density; and, as the temperature is reduced, its volume increases, until at 32 degrees it crystallizes into ice, when the volume is increased from 1,000 in water to 1,068 in ice. If water is still, the temperature may fall to 20 degrees ere it crystallizes; but if suddenly jarred when the temperature is below

to escape, if possible, past the stream; but, in doing so, I tripped and fell close under the stream where it struck the wall. Hastily gathering myself up, I made my exit from that point. As soon as I got out I was surrounded with friends, who thought me fatally scalded. I assured them that I was not hurt, but I confess I was badly scared.

I have stated this case to show that I was twice under a 4 inch stream, and was not scalded, in fact, I felt while under it as if being drenched by both a hot and colder current at the same moment. On the other hand, I did get pretty badly scalded in the attempt to escape through the roof, and was conscious of the fact at the time.

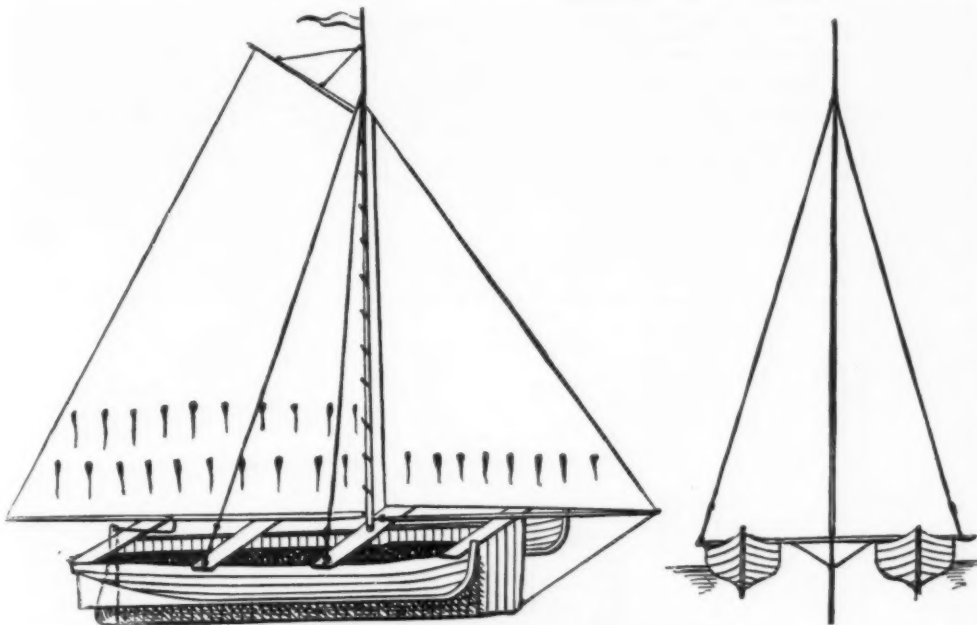
Some eighteen years ago, in the investigation of this question, I had an opportunity of demonstrating the comparative expansive force of steam and superheated water. The steam cylinder of the Monongahela water works was 26 inches in diameter by 10 feet stroke; two boilers of 40 inches diameter by 28 feet long, with two 14 inch flues in each boiler. The cubic contents of the steam cylinder were equal to one-fourth of the steam room, two boilers and steam drum, and one-eleventh and a half of the entire cubic contents of the steam drum and two boilers. The engine made six double strokes per minute, and used steam only on one side of the piston. Out of the ten seconds required to make a double stroke, the steam was drawn from the boilers less than four. During each draught of the cylinder on the boilers, steam gauge showed a reduction of 1 1/4 pounds; and in the interval of six seconds in which no steam was drawn, it had risen to its normal pressure of 100 pounds, assuming the laws governing the generating and working of steam expansively to have operated in these boilers similarly to those in others. As the capacity of the cylinder was equal to one-fourth of the steam room of the boilers, on the assumption that there was no expansion of the water, the pressure at each stroke should have been reduced some twelve or thirteen pounds. Taking the whole cubic capacity of the boilers, which was eleven and a half times that of the steam cylinder, if the water only expanded equal to that of the steam, the pressure should have fallen some four and a half pounds; the fact that it was only reduced one and a fourth pounds demonstrates not only that the water expanded, but to a much greater extent than the steam.

During the war I was consulted by a gentleman having charge of the machinery on one of the government gun boats. He informed me that the gun boats had been furnished with apparatus for throwing scalding water, to be used either in offense or defense, but that on trial the whole project had proved a failure. To my inquiries he stated that when the water was first turned on, the stream would throw from 100 to 200 feet and the water scald, but in a few seconds the distance the water was thrown was reduced to 20 or 30 feet, and would not scald at a distance at 10 feet from the nozzle. He was advised to provide the boats with heaters separate from the boilers, and the water to be thrown heated to a temperature not exceeding 200 degrees. He was also informed that the cause of their failure was that the water they had attempted to throw was heated over 300 degrees, which expanded as soon as it was released from the pressure of the nozzle, and the reason the water projected so far at first was owing to its being drawn from the mud drum or stand pipe in which the temperature was below 212 degrees.

There are times when a knowledge of this law, that water and steam escaping from a boiler under high pressure will not scald, might be of great service. As an instance, had the men in charge of the trains the night of the terrible catastrophe on the Pennsylvania Railroad promptly broken all the windows in the coach telescoped by the engine, to admit the air, there might have been saved many lives and much suffering.

Renwick's Natural Philosophy, published forty years ago, states that steam escaping from a boiler with a pressure of two atmospheres will not scald. A strong proof of this statement was demonstrated in the case of Messrs. Christ Miller and Edward Mealy. The two young men were within 15 or 20 feet of the Sligo boilers when they exploded. They were both drenched with steam and superheated water, but were only burnt in spots, caused by being buried under the hot bricks which pressed on their wet clothes. I went over to look at the results of the explosion. The general opinion seemed to be that the cause of it was lack of water in the boiler. There was certain evidence tending to support that conclusion, but on a closer examination I was impressed with the conviction that the boiler was full at the time of the explosion. The parties from whom the circumstances might be ascertained were badly wounded. As soon as Mr. Miller recovered, I called on him, and to inquiries he replied: "Mr. Allen, who was killed, had charge of the boiler, and was a careful man. I am certain I saw the water either in the first or second gauge on stopping for dinner at 12 M. Mr. Allen was in the habit of filling the boilers at dinner time, but I do not know that such was done on that day. When starting the engine at 1 o'clock, a joint in the steam pipe blew out. At a quarter past 1, the safety valve was blowing off steam. Mr. Allen said he would open the mud valve to relieve the boiler. I asked if he wanted assistance, but he answered no. At that moment he opened the mud valve, when the boiler instantly exploded."

The boiler plates were made of piled iron, stamped 57,000 pounds tensile strength, 3/8 of an inch thick, and single riveted. The boiler was 34 feet high. The upper 10 feet was made 38 inches in diameter and used as a dome, or steam drum. The lower 24 feet was made 48 inches in diameter, and was inclosed in a circular fire wall. The boiler heads were of wrought iron some 5/8 of an inch thick. The mud valve was 2 1/2 of an inch in diameter, and connected with the lower head. The steam pipe projected to within 6 inches of the upper head of the dome, and was carried down the center of the boiler and taken out through the side. On this steam pipe the safety valve of 3 1/2 inches diameter was fitted. The whole boiler appeared in good condition with the exception of the lower sheet, which was badly corroded where riveted to the lower head. At one place, for nearly 2 feet, it was reduced in thickness from 3/8 to 2/8 of an inch. The mud valve was found raised 1/8, equal to an opening of 1 inch diameter. The three gauge pipes were respectively carried up to 6, 7, and 8 feet above the upper boiler head. The boiler, when full to the upper gauge, had a depth of 32 feet of water, equal to 2,726 gallons. If all the water in the boiler was evaporated into steam at a pressure of 90 pounds to the square inch, it would furnish steam to an engine of 12 inches diameter by 24 inch stroke, working at a speed of 45 revolutions per minute, for 14 hours and 12 minutes. If this boiler was filled to the upper gauge before starting to work at 7 in the morning, and no water supplied, there should have been 18 feet 10 inches depth in the boiler at noon. The mud valve, 2 1/2 inches in diameter, was raised 1/8 of an inch, the open-



DEEP CENTER-BOARD CATAMARAN.

water cannot explode. To this erroneous belief, in my opinion, may be traced many of the most disastrous explosions. An engineer, believing that a boiler filled with water cannot explode, knowing that the boilers under his care are well filled, apprehends no danger, while the steam may be higher than the tensile strength of the iron will bear with safety.

Water under 212 degrees, with sufficient pressure, will burst a boiler but not explode it. If a boiler burst with water in it at temperature over 212 degrees, say 300, there will be an explosion, owing to the elasticity of the high temperature of the water.

In support of the above statement, I will quote the laws governing the generating of steam, and the opinions and experiments of eminent scientists and engineers.

It is admitted by all recognized authorities that water is composed of oxygen and hydrogen, by weight eight parts oxygen to one of hydrogen; by volume, two parts hydrogen to one of oxygen. That steam or vapor is a compound of water and heat, or caloric. That water in a vacuum will only absorb some 80 degrees of heat, ebullition taking place at that temperature; but if the water be removed from the vacuum, it will cease to boil until the temperature rises to 212 degrees—at sea level. Question.—What is the cause of water requiring 132 degrees more heat to boil at the sea level than in a vacuum? Answer.—There is one atmosphere equal to 14.73 pounds pressure on the surface of the water, at sea-level, and no pressure on the water in a vacuum. If the cause for the difference in the boiling point of water in a vacuum and under one atmosphere is as stated, the question naturally follows. If a pressure of one atmosphere raises the boiling point of water 132 degrees, to what will the boiling point be raised when under a pressure of ten atmospheres, equal to 147.3 pounds? If the temperature of the water equals the temperature of the steam with 147.3 pounds pressure, the boiling point of water, under ten atmospheres, will be 302 degrees. Now assuming that the temperature of the water in a boiler, under a pressure of 147.3 pounds to the square inch, instantly explodes, what becomes of the 150 degrees more than is required to boil the water at one atmo-

32 degrees, it will instantly form into ice. As the temperature of the water is raised above 38.5 degrees, its volume is increased. Hasseler states that water can be boiled in a vacuum at from 60 to 80 degrees, depending on the perfection of the vacuum; but, under a pressure of one atmosphere—at sea level—it cannot be boiled at a temperature less than 212 degrees. At this temperature—212—the water ceases to absorb more heat, and generates steam, the volume of the steam being in proportion to that of water as 1,696 is to 1.

A scientist, whose address I have forgotten, states that in a number of experiments he demonstrated that the sudden agitation of water increases its temperature.

Other authorities might be cited if necessary.

Some thirty-six years ago, my attention was first directed to the fact that water escaping from a boiler, under a pressure of 80 pounds, the temperature at 312, would not scald. In the investigation of this to me strange phenomenon, I became impressed with the conviction that the expansive or explosive force of the water, under so great pressure, was the cause of its not scalding. Having a boiler that needed cleaning, and not having time to stop, I filled it full of water, raised the steam to 80 pounds, then drew the fires and opened the valve for the purpose of blowing out any sediment in it. But in raising the valve, the cap covering a 4 inch opening in the lower side of the boiler head blew off; instantly a 4 inch stream of boiling water was projected from the boiler, creating such concussion as not only to shake down an old building adjoining, but also to alarm the people for squares distant. For a moment the cap only blew partly off, but in such a position as to direct the water and steam on me. Although feeling no scalding sensation, I did not stand long on ceremony, but got out of the way. The cap, after an instant, came off entirely, and the jet of water was projected through a door against a brick wall, some 9 feet distant. In a few seconds, the boiler house was filled with steam which arose from the escaping water, and began to get unpleasantly hot. To escape, I had either to make my exit through the roof or pass close by the stream of water where it struck the wall, and which, I thought, would surely scald me. I made the attempt to escape through the roof, but was compelled to relinquish, on account of the intense heat of the steam. I then determined

* A paper read before the Engineers' Society of Western Pennsylvania, November 2, 1883, by Jos. L. Lowery.—American Engineer.

ing not equal to a 1 inch nozzle, while a fire engine, with a pressure of 300 pounds, will only throw through a 1 1/2 inch nozzle 7 gallons per second.

From the above it will be seen that as the mud valve was not opened over three seconds, not more than 20 gallons—3 inches in depth—was drawn from the boiler. An examination of the fragments of the boiler does not, in my opinion, indicate that low water was the cause of the explosion. The upper 10 feet of the boiler is still connected with the dome, and shows no indication of being burned. If there was a deficiency of water, the upper end would be the first subjected to the fire, and show strongest evidence of injury, therefore first to give way. On the contrary, the very lowest sheet on the boiler, 12 inches below the fire line, was the point, in my opinion, that first gave way. When the explosion took place the whole boiler, except the lower head, seems to have risen bodily; the lower 14 feet of the shell was torn into fragments; the upper 10 feet and the dome were projected some 800 feet in height. No one doubts but that there was water in the lower end of the boiler. Will any one believing in the low water theory state why the boiler first ruptured before the fire line, and where undoubtedly there was water? It is a reasonable inference that the custom of filling the boiler at dinner time was carried out on the day of the explosion; and that Mr. Allen, thinking there was too much water, proposed to relieve the pressure by drawing some of the water out. To what other hypothesis can his action be accounted for? From the evidence stated I am strongly of the opinion that the boiler was full of water, and the cause of the explosion was the greater pressure of steam on the weak and corroded end of the boiler than it was able to bear. Possibly the overpressure was, in part, caused by the boiler being filled too full, and water overflowing into the steam pipe obstructed the free exit of the steam. The blowing out of the joint in the steam pipe indicates either concussion by water or high pressure.

The great height to which the boiler was projected is evidence, not only of a high pressure, but also that it was full of highly superheated water.

On the 2d of the present month, a large double-flue boiler at the glass works of Mr. Price, located at Homestead, was burned so badly as to render it worthless. Mr. Price states that the first intimation of anything wrong was the very strong smell of burning iron and sediment in the boiler, but not suspecting the cause, a general search for the supposed fire was made without finding it. After some time the engine reduced its speed to such an extent as to prompt the persons in charge to stir up the fires.

On opening the furnace door he observed the whole bottom of the boiler red hot.

An examination showed that all the water had either been evaporated or run out through the opened seams and cracks in the bottom of the boiler.

As this is only one of many cases that have occurred in the past thirty years, the question may be asked, If want of water is the cause of explosions, why then did not this boiler explode? The boiler plates were warped and scaled, seams opened, and there was no water in the boiler. If it had not been for the odor from the burned boiler, and the decreased speed of the engine, no attention would have been given the boiler at the time. The reason of no explosion in this instance is, to make an explosion possible there must be water present to generate the force required to make an explosion. In this case the water was all gone out of the boiler, taking with it that force.

The difference between the condition of the Homestead and the Sligo boilers is so apparent as to attract attention. Only a portion of the Sligo boiler sheets was warped, but showed no scale from heat being in the lower part of the boiler. Had there been a lack of water, these sheets would have been the shortest time subjected to the fire. None of the seams were opened, nor has any one stated that they observed any odor from the burning boiler. The evidence strongly forces the conviction that the cause of the Sligo boiler explosion was not for the want of water in the boiler, but a higher pressure of steam than the tensile strength of the iron in the corroded part could sustain. While strongly dissenting from what I conceive to be an erroneous belief, I desire to be understood as implying no reflection on the memory of Mr. Allen.

Only some two or three years ago an investigation was held before the coroner on the cause of the boiler explosion at the Keystone mill. Among the witnesses were three gentlemen, long engaged in the engine and machinery business, who testified that no boiler filled with water could explode. If such men give expression to this belief, are others to be blamed for following their views?

It may be asked, If carrying high steam is the cause of explosions, why not reduce the pressure, say, to one atmosphere? There are two objections to this: 1, to reduce the pressure would require much larger steam cylinders to do the work; 2, the increased cost of fuel.

At a pressure of 1 atmosphere, to raise the pressure of steam 2 pounds requires the temperature of the water to be raised 6.8 degrees. To raise the pressure of steam 5 pounds above 7 atmospheres, or 105 pounds, requires the temperature of the water to be raised only 3.4 degrees. It will be observed in the first case, it requires an increase of 3.4 degrees to raise the pressure of the steam 1 pound, while in the second it requires the same number of degrees—3.4—to raise the pressure 5 pounds.

A non-condensing engine working with a steam pressure of 30 pounds—which is 15 pounds above the atmosphere—is required to exhaust against a resistance of 15 pounds, the atmospheric pressure. This is a loss of 50 per cent. of the power exerted on the piston. An engine working with 100 pounds pressure on the piston exhausts its steam against 1 atmosphere, only losing 15 per cent. of its power, while an engine, working with 300 pounds pressure on the piston, and exhausting as before stated, loses only 5 per cent.

For the above reason it will be seen that for a non-condensing engine, the higher the steam is carried the more economical it will work. Carrying high steam is not necessarily dangerous, as boilers can be made to bear any desired pressure with safety by their being adapted to the work required.

All boilers, either for high or low steam, should be made of best plate, properly riveted and calked. Where high steam is required, the boiler plates should be made thicker in proportion to the work required, or what is better, reduce the diameter of the boiler where practicable.

With a boiler properly adapted to its work, all that is required of the engineer for the preservation and safety of the boiler is:

To keep it free from all sediment and scale.

In cleaning, not to permit the water to be drawn from the boiler until the furnace is sufficiently cold.

Not to hasten the cooling of the boiler by flushing with cold water.

To see that the fire line of the furnace wall is kept below the water line in the boiler.

To guard against carrying steam any higher than will leave a proper margin for safety.

To feed it regularly and in such a manner as not to come in contact with the boiler plates, until it is of the same temperature as the water in the boiler.

The water, in my opinion, should be fed through the top of the boiler into the steam either in spray or thin sheets, in order that it may acquire more readily the same temperature before coming in contact with the body of the boiler.

I do not believe that a boiler can be blown up by cold water being fed into it, if the water can be properly distributed so as to be kept from touching the boiler plates;

THE MECHANICAL MANUFACTURE OF TOILET SOAP.

THE series of machines illustrated herewith has been devised by Messrs. Beyer Bros., of Paris, for the mechanical manufacture of toilet soaps. Fig. 1 represents a powerful mixing machine provided with granite cylinders, and the object of which is to crush up the soap in a dry state and mix it with the perfumes and coloring materials. The mixing is accelerated by toothed knives, which are affixed to the interior of the hopper, and which divide the soap into ribbons after every passage between the cylinders. The homogeneous paste furnished by this machine has to be converted into smooth, compact bars, in order to be divided into cakes that

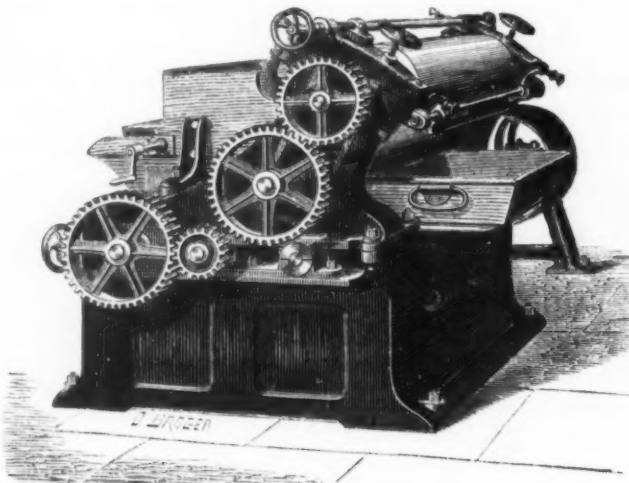


FIG. 1.—CRUSHING AND MIXING MACHINE.

but the danger is in allowing the water to come in contact with some part of the boiler, causing that portion to shrink, which results in a crack, and possibly an explosion.

SUGGESTIONS.

In order to prevent, if possible, such catastrophes as have so frequently occurred in this community, and for the purpose of diffusing such information as is requisite for the preservation of life, I suggest that the law for the inspection of boilers be amended so as to authorize and require the county boiler inspector to have prepared such brief and simple regulations as are requisite for the information of those having charge of steam boilers. Said inspector to be required to furnish a copy of said rules to each proprietor and engineer in charge of boilers. That it shall be the duty of such parties to make and forward to the county inspector on the first days on January, April, July, and October, a true

will afterward receive the manufacturer's mark. In order to effect this, the Messrs. Beyer have devised two types of squeezing machines. The squeezers shown in Figs. 2 and 3 consist of a cylinder surmounted by a pestle arrangement that rams down the soap in measure as it is introduced, and expels the air that it contains. When this operation is finished, the pestle support is swung around, and the hinged cover is fastened down upon the cylinder so as to close it hermetically. In the interior of the cylinder there is a piston which is actuated by an endless screw and gearing, as shown in Fig. 2. It is only necessary to raise this piston to cause the compressed soap to make its exit through the orifice, D, where gauge plates determine its section. The bar of soap, on making its exit, is sliced into cakes of the desired weight by means of a rotary knife placed in front of the machine. This kind of machine has been extensively adopted by perfumers, and is in operation everywhere where

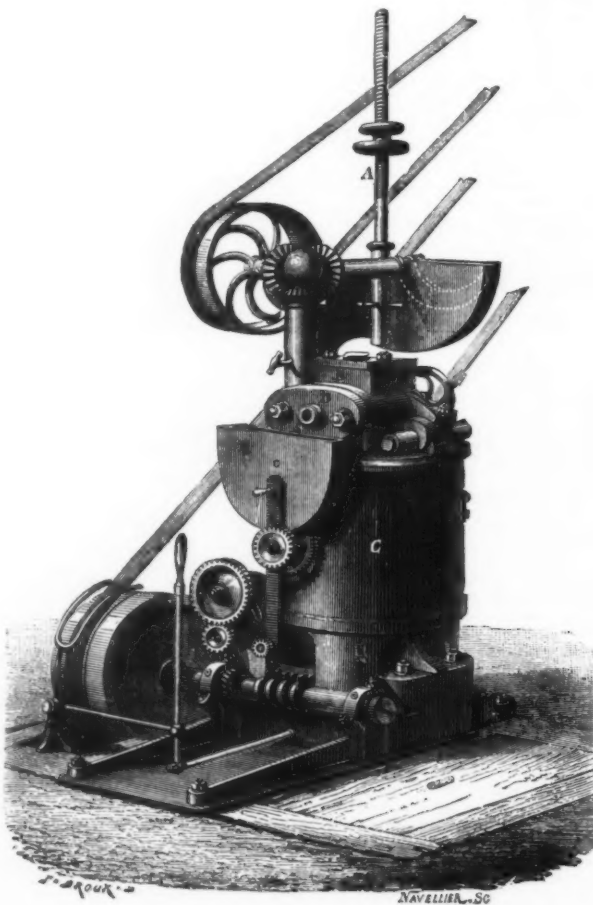


FIG. 2.—SQUEEZING MACHINE.

written report of the operations and present conditions of the boilers in their charge for the past three months.

That the boiler inspector be authorized and required to enforce obedience to such rules as have in view the preservation of life, by the prosecution of both proprietors and parties in charge for the neglect or refusal to comply with the said rules and regulations.

extra fine soaps are made. For the manufacture, on a large scale, of toilet soaps that are largely consumed, however, the machine shown in Fig. 4 is preferred. The cylinder of this machine, which is paraboloid, is of cast iron, and is adapted to a box which contains the driving mechanism and is affixed to the frame of the machine. In the interior of the cylinder there is an Archimedes screw which is set in mo-

tion by the above mentioned mechanism. This screw, which is very strong, works by slight friction in its sheath, and is adjusted with the utmost precision. The inclination of the threads is such that their generatrix remains at right angles with the surface of the paraboloid cylinder. The slow revolution of the screw effects a compression of the material treated, and expels all air therefrom. This strong and continuous thrust expels the paste through a bronze orifice which is heated by hot water, and upon which are mounted gauge plates. The paste makes its exit in the form of a compact, smooth, and shining bar.

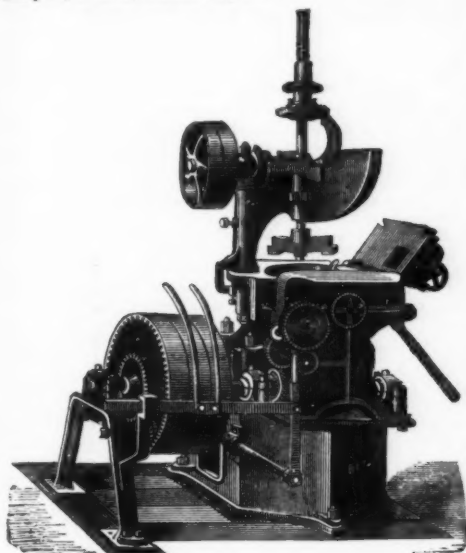


FIG. 3.—SQUEEZING MACHINE.

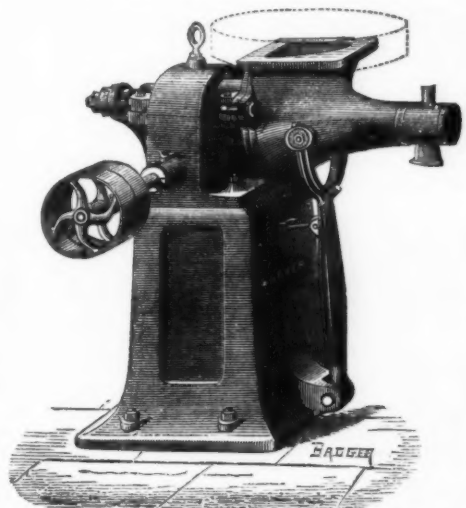


FIG. 4.—CONTINUOUS SQUEEZING MACHINE.

The production of this new machine is very great; the largest size, combined with the new 4-cylinder mixing and crushing machine, manufactures the respectable number of 10,000 cakes per day.—*Moniteur Industriel*.

CONSTRUCTION OF STABLES.*

By AUGUSTINE W. WRIGHT.

THE United States Census of 1870 gave the number of horses owned in the U. S. as 8,690,219. When the Census of 1880 was taken there were 12,170,296 horses, mules, and asses on the farms alone. Our own State of Illinois leads with 1,146,380!

Anything affecting the monetary value of this vast multitude is of importance to the individual owner, to the State wherein he resides, to the nation of which he is a citizen!

We appeal in vain to history to inform us when mankind first subjected this, the most noble of the brute creation, to his service in times of peace and times of war! The date is lost even to tradition, but that he served in the dawn of mankind, the sublime words of Job bear witness:

"Hast thou given the horse strength? Hast thou clothed his neck with thunder? Canst thou make him afraid as a grasshopper? The glory of his nostrils is terrible. He paweth in the valley, and rejoiceth in his strength; he goeth on to meet the armed men. He mocketh at fear, and is not affrighted; neither turneth he back from the sword."

Prescott tells us of his service with the Spaniards in their conquest of Mexico. In short, the debt of humanity to this noble animal cannot be overestimated, and every language has been used to sing his praise!

The artificial restraint imposed upon the horse by mankind during so many centuries past has had its effect, and he resembles his master in many diseases.

From a sanitary point of view late years have witnessed great advancement in the construction of buildings for mankind, and the cry for better stable accommodations has not been uttered entirely in vain.

Permit me to quote a few from the many writers upon this important subject.

John Stewart wrote: "Stables have been in use for several hundred years. It might be expected that the experience of so many generations would have rendered them perfect. They are better than they were some time ago. . . . A damp stable produces more evil than a damp house. . . . Since 1789, when James Clarke's work was published protesting against close stables, there has been a constant outcry against hot, foul stables. Every veterinary writer who

has had to treat of diseases has blamed the hot stables for producing at least one-half of them." Jennings wrote: "The most desirable thing in a stable is ventilation. A horse requires air equally with his master; and as the latter requires a chimney to his sleeping room, so does the former." Henry W. Herbert, better known as Frank Forester, wrote: "In a climate so uncertain, changeable, and in which the extremes of heat and cold lie so far apart, as in this country, the question of stabling is one of paramount importance. The stable, to be of real utility, must be perfectly cool, airy, and pervious to the atmosphere in summer; perfectly close, warm, and free from all draughts of external air, except in so far as shall be needed for ventilation, in winter; perfectly ventilated, so as to be pure and free from ill odors, ammoniacal vapors, and the like arising from the urine and excrement of the animals, at all times perfectly dry under foot and well drained, since nothing is more injurious to the horse than to stand up to its heels in wet litter. . . . Lastly, it should be perfectly well lighted, as well as thoroughly aired."

Stonehenge wrote: "The horse, like all the higher animals, requires a constant supply of pure air to renovate his blood, and yet it must not be admitted in a strong draught, blowing directly upon him, or it will chill the surface and give him cold. . . . By common consent it is allowed that no stable divided into stalls should give to each horse less than 800 or 1,000 cubic feet."

Youatt wrote: "It is not generally known, as it should be, that the return to a hot stable is quite as dangerous as the change from a heated atmosphere to a cold and biting air. . . . It is the sudden change of temperature, whether from heat to cold or from cold to heat, that does the mischief, and yearly destroys a multitude of horses."

One more quotation, from John Osgood, who, in speaking of city stables, said: "Now, in the name of humanity and ordinary commercial thrift and sagacity, let this be stopped. There is no reason why stables should be horse bells! No reason why they should vie with 'the Black Hole' in their inevitable cruelty, and gloom, and destruction. These and city stables generally (with some exceptions) are a disgrace and a shame to a civilized community. So long as they continue as they now are, horses must die. There are no remedies for the sudden and violent diseases which will attend such poisonous air and water and food. The remedy lies in providing ample and well ventilated stables—stables well lighted, with stalls of ample dimensions, with escape pipes for the ammoniacal effluvia which arise from so many animals and their excretions, with more room for evaporation; and then the chances would no longer be against every horse who passes through these doors, as they were against those ghastly ones who passed through Dante's gate, and, as they went in, read above their heads:

"Who passes here goes into everlasting hell."

"Improve the stables, then, and prevent disease. Do not insult a respectable animal who has come from the country to do his share of the work of the world, and has brought with him the memory of the sweet hills and skies, at least, by immuring him in one of those cramped, rickety, rotten, stinking, slovenly, damp dungeons, where a dumb beast would lose his self-respect and his courage beneath an oppressive weight of miasmas and hideous, gloomy, nasty confusion. Stop this, or pray that horses may die ere the evil days come."

The above, if it have weight, must convince you that badly constructed stables are responsible for many, very many, of the diseases among horses. The paramount importance of abundant sunlight, perfect sewerage, and good ventilation is now, fortunately, recognized almost universally in building human habitations, but how often ignored in providing quarters for the horse, the number sick and unfit for duty most eloquently testifies.

I will now describe a stable just finished for the North Chicago City Railway. It fronts south 125 feet upon Belden avenue, east 238 feet upon Jay street, both of which streets are 66 feet wide. Along the west side there is an alley 16 feet wide, and 50 feet left vacant, extending to the Car House. On the north our property extends 12 feet beyond the stable. We therefore have light and ventilation upon four sides. The horses face north and south. In the rear of each row of horses there is an alley extending clear across the stable, 10 feet wide, with a sash door 7 x 10 feet at each end. Another alley 9 feet 6 inches wide extends the length of the stable at right angles to the former, with sash doors 7 x 10 feet at each end. The stalls are 9 feet deep, and each horse is allowed 56 inches of width. Double stalls are in my opinion the best, when horses will stand quietly together. So many of our horses will not do this, that I alternate two single stalls with one double stall, thus allowing the foreman to place the horses who will not stand quietly in single stalls. The floor of this stable consists of four inches of asphalt with 2 x 4 inch scantling bedded therein; 16 inch centers, to which the wearing floor of 2 inch pine is spiked. The stalls have an inclination of 2 inches, terminating in a gutter connected with the sewer. These gutters are covered with cast iron plates 56 inches long by 6 inches wide, perforated to allow the urine to pass into the gutter. These covers are movable, and at least once a week the foreman of the stable sees that they are taken up and that the gutters are thoroughly cleaned. Some disinfectant should be freely used. Between each row of horses there is a "feed alley" four feet wide. By this construction the horses are not brought head to head to breathe each the other's breath, contaminated, it may be, by disease, which is thus spread from one to another. No food is wasted in placing it in the manger; and there is less danger of an employee being injured or perched crippled for life by some vicious or frightened horse. At each end of these feed alleys windows are placed containing 32 lights 9 x 14 inches, a size of glass I have adopted as a standard and use whenever possible, to avoid carrying a stock of different sizes. In these feed alleys beneath the floor there are placed fresh-air ducts, extending from outside to outside of the stable, through which air is admitted, passing out into the stable through perforations in the cover, thus avoiding injurious draughts. Its exterior openings are protected by cast-iron grates built in the brick work, preventing the entrance of all vermin, and especially the pestiferous rat! In this stable there are 9 ventilators, one located at the intersection of all alleys, for the exit of foul air. They are 6 x 6 feet at the lower end and taper to 4 x 4 feet at the top, extending 8 feet above the roof. The four sides above the roof are movable (except the posts), inclining at an angle of 45°, thus deflecting the air upward and doing away with all downward currents and permitting the opening to be reduced in cold or inclement weather, ropes extending to the ground floor for this purpose. We are indebted to the veteran in horse railroad matters, John Stephenson, for this admirable idea. It resulted from many experiments made by him upon ventilation while

a member of the New York School Board. The gas burners located under these ventilators assist in ventilation by heating the air, which ascends, and increases the outward-bound current of impure air.

The first story of this stable is 16 feet high, second story 7 feet at walls and 9 at center. Each horse has twelve hundred and sixteen cubic feet of space, an amount fully equal to modern theory requirements. The hay loft can contain one year's supply if needed. The feed department, with bins for storage, troughs 16 feet long, 4 feet high, and 3 to 4 feet wide for mixing feed, cut-bay room, and horse power to run the cutter, is located up stairs. As we use shavings for bedding, and can obtain them cheaply and abundantly in summer when the mills are busy, whereas they are scarce and high in winter, the bedding room is large. On the ground floor it is 16 x 50 feet, and extends open to the roof, with an addition, 16 x 70 feet, on the second floor. The cost of bedding for the horses purchased in this way is one half cent, per diem each.

The hospital, separated from the balance of the stable, is located at the north end, in the most quiet spot. Scales are provided upon which all supplies are weighed. An office for the foreman, room for grooms, another for conductors, and one for storage, are furnished, besides convenient closets, etc. I neglected to state that a number of catch basins are provided to retain all shavings and solid matter that might otherwise get into and obstruct the sewer pipes. These basins are four feet in diameter, and are cleaned out as often as may be necessary. They are trapped to prevent sewer gas from entering the stable; all the roof water is used to flush these sewers. The building will be whitewashed in the fall, for health and comfort.

The above brief description will serve to give you an idea as to how far I have succeeded in putting in practice the requirements of theory. The stable has abundance of fresh air, contaminated air is removed, and there is good sewerage and plenty of light. The small percentage of horses in our hospitals most emphatically indorses the construction.

I think with Youatt that the stable should not be too warm in winter. Nature is a safe guide, and she provides the horse with a suitable covering. The stable temperature in my opinion should not vary more than 10 or 20 degrees from the external air. Keep the stable cool, and, if necessary, throw a blanket over a horse while hot, just in from work, during severe winter weather. Our car horses pass twenty of the twenty-four hours in the stable, and the importance of thorough sanitary arrangements is, of course, thereby increased, as the majority of horses used in other lines of business spend scarcely more than one-third as much time in the stable.

"A merciful man is merciful unto his beast," but the most refined selfishness, if intelligent, should cause each and every one with capital invested in horse-flesh to give it "suitable stable accommodations." Were my pen capable of expressing all I feel, most eloquent would be my appeal in behalf of the noble brute for whom I have ever entertained the deepest affection.

COPPER MINERALS.

COPPER occurs in a variety of forms, but many minerals containing it are much too poor to allow of its profitable extraction. It is found in combination with sulphur as a sulphide or sulphuret, with oxygen as in oxide, and with carbon, hydrogen, and oxygen as a hydrated carbonate. It is found also native and associated with most of the metals, common or rare. It is obtained for use mainly from native copper, cuprite, melanconite, azurite, malachite, chalcocite, chalcophyllite, and tetrahedrite.

To such persons as are interested in copper mining, a list of the principal copper minerals found in the United States, and their composition, will be of value for reference. There are many of them, most of them having one or more common names by which miners know them, as well as names by which mineralogists know them. We shall give the list in alphabetical order, with the scientific and common name, and the composition:

- Aikinite (needle ore, acicular bismuth, cuprous bismuth). Composition—copper, bismuth, lead, and sulphur.
- Algodonite (arsenide of copper). Composition—copper and arsenic.
- Atacamite (muriate of copper, oxychloride of copper). Composition—copper, chlorine, oxygen (water).
- Aurichalcite (carbonate of zinc and copper). Composition—copper, zinc, carbon, oxygen (water).
- Azurite (mountain blue, blue carbonate of copper, blue malachite, azure copper ore). Composition—copper, carbon, oxygen (water).
- Barnhardite (sulphide of iron). Copper, iron, and sulphur.
- Bornite (purple copper ore, variegated copper ore, *esmeralda*, sulphide of copper, and iron). Copper, iron, and sulphur.
- Bournonite (triple sulphuret of copper, lead, and antimony). Copper, lead, antimony, and sulphur.
- Brochantite (sulphate of copper). Copper, oxygen, sulphur (water).
- Caledonite (cuprous sulphato-carbonate of lead). Copper, lead, carbon, oxygen, and sulphur.
- Carrollite (sulphide of cobalt and copper). Copper, cobalt (nickel), and sulphur.
- Chalcantite (blue vitriol, copper vitriol, sulphate of copper). Copper, oxygen, and sulphur (water).
- Chalcocite (copper glance, vitreous copper, sulphuret or sulphide of copper). Copper and sulphur.
- Chalcophyllite (copper pyrites, pyritous copper, sulphuret or sulphide of copper). Copper, iron, and sulphur.
- Chrysocolla (mountain green, mountain blue, silicate of copper). Copper, silicon, oxygen (water).
- Covellete (indigo copper, blue copper, sulphide of copper). Copper and sulphur.
- Cuprite (red oxide of copper, cuprous oxide). Copper and oxygen.
- Domeykite (arsenical copper, arsenide of copper). Copper and arsenic.
- Enargite (sulph-arsenite of copper). Copper, arsenic, and sulphur.
- Harrisite (sulphide of copper). Copper and sulphur.
- Malachite (mountain green, green carbonate of copper, green malachite, green copper). Copper, carbon, and oxygen (water).
- Melanconite (black oxide of copper, black copper, cupric oxide). Copper oxygen.
- Native copper (sometimes with silver). Copper (silver).
- Pseudomalachite (phosphate of copper). Copper, oxygen, phosphorus (water).
- Stromeyerite (sulphuret of silver and copper, silver-copper glance). Copper, silver, sulphur.

* Read July 13, 1884, before the Western Society of Engineers.

Tennantite (sulph-arsenite of copper). Copper, sulphur, arsenic (iron).

Tetrahedrite (gray copper ore, sulphide of copper and antimony, with various other sulphides). Copper, antimony, sulphur (arsenic, bismuth, silver, mercury, zinc, etc.).

Torbernite (copper-uranite, phosphate of uranium, and copper). Copper uranium, phosphorus, oxygen (water).

Uranochalcite (oxide of uranium with oxide of copper and sulphate of lime). Copper uranium, oxygen, sulphur, calcium (water).

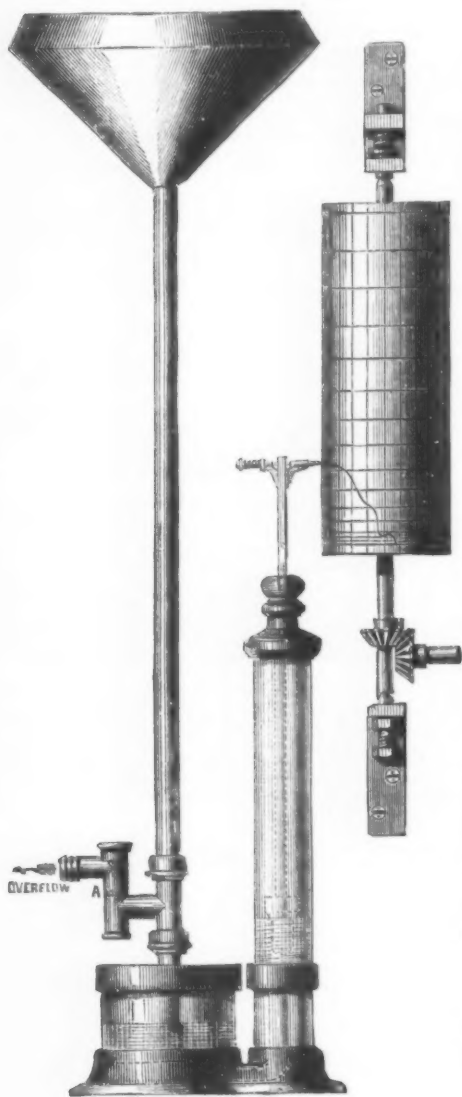
Vauquelinite (chromate of copper and lead). Copper, lead, chromium, oxygen.

Whitneyite (arsenide of copper). Copper and arsenic.

Of course many of these copper minerals are not such as are worked for copper. The list, which is from the appendix of Brown's Manual of Assaying, is given merely as a matter of reference, so that miners knowing the common name may know the mineralogical name and composition of the mineral. —*Min. and Sci. Press.*

SELF-RECORDING RAIN GAUGE.

MR. A. JACOB, of Salford, has contrived an instrument which gives a perfect record of the rate at which rain descends at any moment during the day and night. *The Engineer* says: The instrument consists of two cylindrical vessels of different heights fixed vertically, and connected with each other at the bottom, so that when a certain quantity of mercury is introduced it will stand at the same level in both vessels. To the top of the shorter cylinder is at-



RECORDING RAIN GAUGE.

tached a tube of the form shown in the engraving, which is connected with an ordinary funnel or rain gauge, either square or circular. The funnel is fixed at a height of several feet above the instrument, for convenience on the roof of the building in which the instrument is placed. Within the tube at the point, A, is fixed a disk of agate or other hard material, which has in it a small perforation, through which the rain water issues after it is caught by the funnel, and passes into the connecting pipe. Within the taller cylinder a float is placed, which rests on the surface of the mercury. To float a stem is attached, which passes between a pair of rollers at the top of the cylinder, and upon the stem is fixed a punch, which presses by the action of a spring upon the surface of a vertical cylinder. This cylinder carries a properly constructed paper diagram, and is caused to rotate by means of a clock, so that one revolution of the cylinder is made in twenty-four hours. The circular motion caused by the revolution of the cylinder, when combined with the vertical motion of the punch actuated by the rise and fall of the mercury, produces a continuous curve, which shows the time and amount of rainfall with accuracy.

When rain begins to fall, it is received by the funnel, which has an area of a definite number of square inches. From the funnel it passes through a small straining chamber down an ordinary service pipe of about $\frac{1}{2}$ in. diameter to the shorter cylinder. Here the water in the pipe exercises a pressure on the mercury due to the charge or height at which it stands in the pipe. The water at the same time escapes through the orifice in the disk fixed at A, at a speed which is proportionate to the pressure, and passes away by an overflow to a vessel in which is measured the total daily rainfall. As the amount of water which escapes bears a fixed propor-

tion to the head in the pipe leading from the funnel, this height may be taken as the measure of the rainfall for the time being. The pressure on the surface of the mercury in the short cylinder raises the column in the longer cylinder to a height which is proportional to the charge of water above the overflow, but in the inverse ratio of the specific gravities of mercury and water.

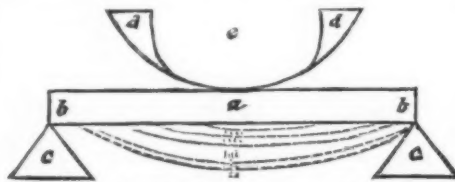
The float is somewhat peculiar in shape, and it is provided with four small pins or studs which prevent it from touching or coming very near to the inside of the cylinder; thus the deranging effect of clinging to the cylinder by capillary attraction is counteracted.

Several cases of legal proceedings against corporations and local boards have arisen from damage caused by the bursting of sewers during heavy falls of rain. At Manchester, Halifax, and Bolton, within five years past, considerable injury has been caused by excessive falls of rain overloading sewers and destroying private property. It is hardly possible, and seldom advisable, to construct sewers of such capacity as to carry away rain storms of preternatural severity, but when local authorities are on their defense, and endeavor to show that the rainfall which caused the damage was excessive beyond precedent, they nearly always fail for want of adequate means of proving their case. It is not sufficient for judges or juries to show them that the total rainfall for the day was very heavy, unless it can be proved to demonstration that the intensity of the fall immediately before the damage occurred was unprecedented, and therefore greater than it was reasonably possible to provide for. In cases of this kind it is that accurate recording instruments are of so much value.

NATIVE CALIFORNIA WOODS.

FIRST its elasticity. For this test the basis is made for a stick precisely one foot square, and thirty feet between the rests, as shown in Fig. 1.

With this crude drawing we will place 1210-239 pounds pressure and find the stick has reached the first line or V., from which it readily springs back to its original position; but if another ounce or gramme weight be added, its plane is forever destroyed, hence, this 1,210 pounds and a fraction represents its actual elasticity, something remarkable when we take into consideration the natural, brittle texture of the wood. Now, by adding 400-7520 pounds more pressure, the timber bends down to the line marked III., and when again freed rebounds back to V., but would, if another atom of pressure was applied, have its second tension strength as represented by a trifle over four hundred pounds. We have now represented by the two pressures 1,610-991 pounds, and the stick permanently bent to all intents and purposes out of true to the extent represented by the arc in the cut. To bend down to III., requires 390-2711 pounds, when the timber goes back, after the weights or pressure is removed, to III., and it will be noticed with the slight addition of 300 pounds and a fraction, the timber made quite a depression, and we will call this the



a—timber; b, b—points 30 feet apart; c, c—rests; d, d—appliance to balance without weight; e—weights or applied pressure, susceptible of being weighed. I, II, III, IIII, V, are represented by the timber when subjected to pressure at E 3 space, 5555 arcs.

third tension, the best tension really of any timber, as will be shown from another series of tests farther on, inasmuch as the wider the space between these lower arcs and the timber going back to the limit of previous test indicates less liability to break beneath first load, if left with inadequate supports. We have now 1,911-2621 pounds pressure, the timber still whole, unfractured, as proved by its power of rebounding back to IIII., and remaining. The fourth tension required an additional pressure of 500-2113 to crowd down to III., when it rebounded promptly to IIII., showing a readiness to bear a greater load and come back to its original shape when the load was removed. We have now applied 2,412 pounds and over, and the timber's formative fabric uninjured, verified by attaining the lower limit of previous test, by the addition of 113-1112532 the timber settled to II., rebounding to IIII., and 16.5 pounds more brought it down to one, when it refused to go any better and respond or make any effort to reach its original position; below this, so far as this test is concerned, the less said concerning it the better; right here began the tests to determine other strengths, which we will refer to again at another time.

It may be stated authoritatively, then, that the various tensions to which the wood has been subjected are represented in the aggregate by 2,547-0844882 pounds before the formative fabric has been disturbed; but the timber is not used up yet by any means, for if the bearing weight of a timber falls short when placed horizontally, it may possibly be placed at certain angles, when it will outstrip all competitors for another test; but to return to our subject. It will be noticed that the point where we applied the weights or pressure to determine these tensions of itself is an arc. It is necessary to have represented the entire length of the timber, so far as bent, with a pressure applied by touching the surface of the timber precisely as represented by each arc below, illustrating the various tensions, otherwise, even if it were possible to bring hydrostatic pressure—the means we employ in laboratory practice—the results would not be accurate, inasmuch as, besides an insurmountable difficulty of applying to the center of the timber, it would not press alike along the line of the depression. We wish to explain these various steps as we pass along, for there will something grow out of these that every architect and builder in the entire country should fully understand.

It has been stated that the timber refused to rebound after further pressure. We will now examine into its structure, and try to ascertain why this is so. If we count the grains in the stick, we find it to contain about 158; these are held in place by the constituent elements of the wood itself, there being no mechanical action whatever. When one of these circles are separated in sawing or any division, these do act slightly mechanically, as was stated in a previous article, by their straightening out; this, too, we may have reason to refer to again.

These chemical elements of which we speak consist of cellulose, gum, starch, gluten, and the like, but we have not submitted the wood to chemical analysis yet, neither can we, until the other tests are further along, for apparent reasons, but will

in due time. If any force is brought to bear having a tendency to displace the molecules constituting these elements, the end of the timber, which was previously perfectly square and smooth, will be notched and jagged precisely in proportion to the accuracy of the previous tests, and when these were completed in this case careful counting revealed just as many of these steps on the end as could be counted grains in the timber, hence the test must be accurate, for the substance situated between each two of these grains had been absorbed or set free from the grains, hence each one of these contained just sufficient elasticity, and no more, to sustain its individual weight, and of course could not spring back. —*Lumber Trade Journal.*

THE TELEPHONE.

By EDWIN J. HOUSTON.

THE telephone is a contrivance by which speech, uttered at one end of an electric circuit, can be heard at the other end, even though the circuit be many hundreds of miles in length.

When a bell is struck, the sound produced is carried to the ear of a listener by means of a wave motion, which the bell makes in the air around it.

Differences in sound are caused by differences in the rapidity with which these waves follow one another.

When sound waves, following each other with a certain rapidity, enter the ear of a listener, they produce therein equally rapid shakings, which, being carried by the mechanism of the ear to the brain, cause a sensation of sound corresponding to the peculiarity of the exciting sound waves.

In electric telephones it is not sound waves that are carried along the line; it is an electric current produced by the sound waves.

There are various kinds of electric telephones.

The magneto-electric telephone consists essentially of a contrivance called the transmitter, into which the speaker talks, connected by a conductor of electricity with a receiver, which the listener holds to his ear.

The atmospheric waves produced by the voice of the speaker, striking against the instrument, into which he talks, cause a plate of iron to move toward and from the pole of a permanent magnet, around which is wrapped a coil of insulated wire. An electric current thereby results, which, flowing over the wire, passes into the receiving instrument, and causes in it a movement that exactly corresponds to the movement produced at the transmitting instrument by the voice of the speaker.

A telephone, therefore, is a dynamo-electric machine driven by the voice of the speaker. The receiver is a dynamo-electric motor, whose rapidity of movements, exactly corresponding to the rapidity of the waves produced by the voice of the speaker, reproduces in the air around it the speaker's voice.

In Fig. 1 is shown, in section, a model of the Bell magneto-electric telephone. It consists of a magnetized steel



FIG. 1.—THE TELEPHONE.

bar, F, with a coil of insulated wire, H, wrapped around it near one of its ends. In front of the coil, so as to be able to freely vibrate to and from the pole, a circular disk of iron is securely fastened at its edges.

A conveniently shaped mouthpiece is placed over the plate, sufficient air space being left for its free vibration. If now a speaker talks into the mouthpiece, the vibrations of the air will cause the plate, which is magnetized by its nearness to the magnet pole, to move to and from the magnet. These vibrations produce in the coil an electric current that flows in one direction when the magnetized plate moves toward the coil, and in the opposite direction when it moves away from it. This instrument is called the transmitter. An exactly similar instrument may be employed for the receiver.

Fig. 2 shows how the receiver and transmitter are placed in circuit with each other.



FIG. 2.—MAGNETO-ELECTRIC TELEPHONE.

Let *a* represent the transmitter, and *b* the receiver, and suppose them to be joined by a conducting wire.

This wire is represented in the figure as broken, so as to give the idea of distance. Suppose, now, a speaker talks at *a*; all he utters can be distinctly heard by the listener, whose ear is held at *b*.

The operation of the instrument is as follows: The effect of the speaker talking into *a* is to cause the magnetized plate to move with varying rapidity toward and from the coil on the magnetized bar. If we can cause exactly similar movements to be produced in the plate of the receiving instrument at *b*, a listener, whose ear is placed near *b*, will hear all that is spoken into *a*.

For, let us consider a single motion of the plate of *a*. Suppose that it moves toward the magnetic pole, and in so doing produces an electric current that flows out of the coil of wire at *a*, and into the coil of wire at *b*, through the ground. This current, circulating around the coil at *b*, causes the magnet to become more powerful, and so draw the plate *b* toward it. If, on the contrary, the plate at *a* moves away from the magnetic pole, the current flows from *a*, in the opposite direction, and passing over the line, flows through the coil at *b*, weakening the magnetism, and thus permitting the plate, by reason of its elasticity, to move from the pole at *b*. The to-and-fro motion of the transmitter, produced by the speaker's voice, has been followed, therefore, by a similar to-and-fro motion of the plate of the receiving instrument, so that whatever is spoken at *a* can be heard at *b*.

In a telephone, therefore, it is not sound that travels along the wires—it is an electric current. The speaker's voice, acting on the transmitter, produces electricity, which, flow

ing over the line, reproduces similar movements in the receiver.

A magneto-electric telephone consists essentially of a coil of wire wrapped on a magnetized steel core, and a plate of soft iron placed so as to be able freely to vibrate very near the pole on which the coil is wrapped, but without touching it.

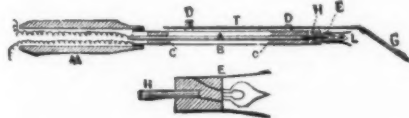
Telephones are made of a variety of forms. In the case we have considered, the receiver is in all respects the same as the transmitter. In some forms of transmitters, such as the Blake, the current of a voltaic battery passes over the line through a resistance which is varied by the voice of the speaker, so that the magnetization of the receiver is correspondingly varied.

In the electrostatic telephone, a system distinct in itself, invented by Dolbear, the speaker's voice varies the electric charge in two metallic plates placed near each other. These plates move toward and from each other when variations occur in their electric charge.—*Electrical Review*.

MARESCHAL'S ELECTRIC LARYNGOSCOPE.

AN examination of the vocal cords and larynx, situated beneath the base of the tongue, presents a certain difficulty, since they cannot be seen directly. We are obliged to have recourse to a small mirror mounted upon a rod at an angle of 135°. This is placed against the veil of the palate so that it faces the larynx, and the latter is thus seen by reflection. Now, it will be readily seen that for this purpose it is necessary to light up the bottom of the patient's mouth brilliantly, and this is done by projecting therein a luminous fascicle produced by a Carcel lamp or, as in Dr. Fauvel's clinic, by an oxyhydrogen lamp. Such an illumination necessitates an arrangement that the physician cannot carry with him when he is called upon to visit a patient at his home. In order to remedy this state of things, Messrs. Cadot & Corneliou have, according to directions from Dr. H. Mareschal, constructed the little apparatus which we illustrate herewith, and in which the lighting is effected by means of a small incandescent lamp placed near the mirror and in the mouth of the patient.

The apparatus consists of an external silvered copper tube, B, and of a concentric copper tube, A, insulated from the other. The flexible conductor, which traverses a wooden handle, M, is connected by one of its wires with the tube, A, and by the other with B. The lamps are absolutely independent, and may be replaced with the greatest facility. To this end, they are mounted at the bottom of a small flaring tube, E, of silvered copper, which serves as a reflect-



or and is adjusted by friction in the external tube, B. One of the wires of the lamp is soldered to the reflector, while the other is fixed to a small copper rod, H, placed in the center of an ebonite cylinder that fits into the tube, A. There is no need, then, of bothering about the securing of contacts, as these are effected naturally when the lamp is put in place.

The laryngoscope properly so called, that is to say, the mirror, G, and its rod, T, is fixed along the external tube by means of two slides, D D, one of which is provided with an adjusting screw. This arrangement permits of moving the lamp to different distances from the mirror, and of easily removing it for cleaning the mirror, or substituting another of different dimensions for it, or for lighting any other natural cavity.

In sum, the physician has here a portable and simple instrument, whose essential parts may be easily kept in good order and be replaced without the aid of a workman. These are valuable advantages that render it really practical.—*La Nature*.

OIL AND ELECTRIC LIGHTS.

In a paper on "Electric Lighthouses," M. De Meritens gives some very interesting figures in comparing oil and electricity as illuminants. The figures, he states, are taken from two memoirs by M. Allard. As an example, the light at Dunkirk, obtained from mineral oil, is 6,250 candles, which in weather of mean transparency is seen for 53 kilometers. If this be compared with an electric light of 125,000 candles, it is found that the electric light is seen for 75.4 kilometers. Thus an increase in the illuminating power of 20 times only increases the penetrative distance 42 per cent. If we now take a less transparent state, the ratio is reduced to an increase from 24 to 32 kilometers, or 34 per cent. Or, lastly, in very foggy weather the distances are 3.7 and 4.6 kilometers, showing an increase of 24 per cent. From these general figures, M. Allard has calculated that in foggy weather in the Channel the luminous intensity with oil of 6,250 candles, is 3.805 kilometers; then, if this be increased to an oil illumination of 125,000 candles, the luminous intensity is 4.740 kilometers. Now, comparing this with an electric light of 125,000 candles, he finds the luminous distance to be 4.696, or the penetrative power of the electric light is less than 1 per cent. less than mineral oil; while its cost, as computed by both English and French engineers, is from four to six times less than that of oil.

ELECTRICITY IN MACHINE BELTING.

A TROUBLESOME development of electricity sometimes takes place with machine belts driven at a high velocity, under favorable conditions. In a dry atmosphere and between shafting practically insulated by wooden blocks, or other non-conducting means of support for the bearings, the pulleys become veritable frictional electric machines, excited by the rubbing of the belting. This subject has recently been reported on by Herr Bacher, inspector of lighting at the Dresden Theater, who has detailed some interesting experiments conducted by himself. He declares that very powerful effects may be produced by this means. A Leyden jar has been charged in a few seconds, giving sparks 4 millimeters long when discharged. A person standing on a stool having glass legs can draw powerful sparks from a belt charged with electricity, by approaching it to the tip of one of his fingers at a distance of 10 or 15 millimeters. All the other well known experiments of frictional electricity may be repeated, in these circumstances, with perfect success. Unfortunately, the development of electricity in belts and pulleys is dangerous; and it is probable that to this cause

many disastrous fires might be attributed which are generally classified as spontaneous. Flour mills, factories in which the air is heavily charged with floating organic fibers of all kinds, are peculiarly subject to these mysterious conflagrations. All lines of shafting, therefore, should be metallically connected, through their bearings, with other masses of metal or with the earth. In humid climates, such as that of Great Britain, risks from the development of frictional electricity to a dangerous energy are comparatively slight; at the same time the possibility is not one that should be altogether lost sight of.

A GAS CARBON BATTERY.

In a paper on the application of electricity as an illuminating agent in astronomical observations, Mr. W. S. Franks, of Leicester, tells the readers of the *Journal of the Franklin Institute* the story of his experiences with incandescent lighting by battery power. His requirements in the matter of lamps were not large, as he only used two of Swan's 2½-candle type, supplied at first by a 4-cell bichromate battery of the usual kind. Ultimately, however, Mr. Franks decided upon a type of home-made battery, which is worth describing, as it may be readily made by any one connected with gas works wishing to make a small private trial of incandescent lighting. He calls it a "granule carbon" battery, and declares that its performance has been to his entire satisfaction. The outer cell is a wide mouthed, two gallon, salt glazed stoneware jar. In this is placed a carbon plate, sawn out from the raw material as obtained at a gas works; its rough edges being merely cut true. There is also a porous cell containing a zinc plate; and both cell and carbon plate are packed into the jar with pieces of carbon broken to the size of a small nut. The jar is then charged with 1 pound of bichromate of potash, dissolved in 1 gallon of hot water, with 1 pound of sulphuric acid afterward added. The porous cell is charged with dilute sulphuric acid, in the proportion of 1 to 10. The three cells are coupled for intensity. When not in use, the zincs are lifted out of the liquid and suspended by loops in the insulated wire connections, upon small nails. The only preparation of the carbon plate was to thoroughly paraffin the exposed end and place a small clip of platinum foil on it, under the brass clamp. This device effectually prevented the destruction of the clamp by acid creeping up the pores of the carbon. It is stated that for the usual intermittent observatory work, the cells will last

Fig. 1

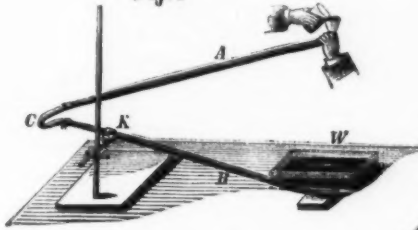


Fig. 3

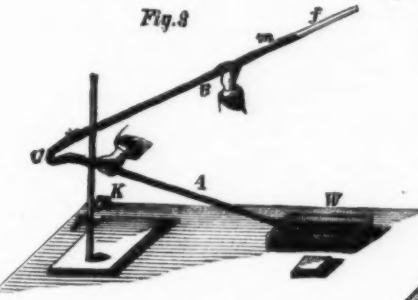


Fig. 2

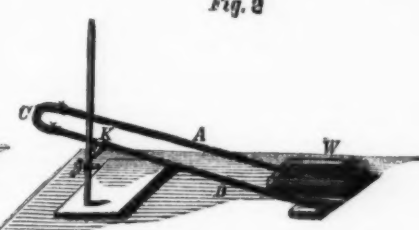
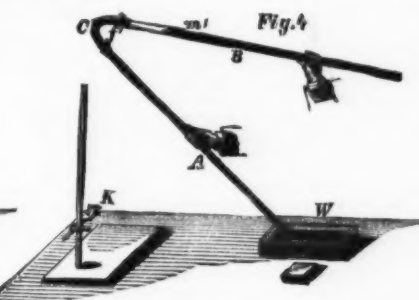


Fig. 4



EXHAUSTION OF BAROMETER TUBES WITHOUT HEAT.

for three months without recharging; though, when required, the lamps can be kept up to full incandescence for hours together. In the ordinary way Mr. Franks put down the expense at about 3d. per week on an average.

EXHAUSTION OF BAROMETER TUBES WITHOUT APPLICATION OF HEAT.

THE defects inherent to the methods at present employed for exhausting barometer tubes have induced V. Klobukow to study the various methods, especially that of Bogen, adopted in meteorological observatories. By a modification of the latter he succeeded in producing a complete vacuum by means of a mercury column without application of heat—Bogen's method. A well dried barometer tube is charged with pure mercury, the imprisoned air removed by shaking, and the orifice closed with the finger, it then is inverted over a mercury trough, partly immersed in the metal, placed in a vertical position, and the surplus of mercury allowed to escape. The tube is again closed by pressing the fingers on to the open end, brought in a horizontal position, and gently shaken for a short time. After a portion of the air embedded in mercury has entered the vacuum, the tube is transferred to the trough, manipulated as before, and the operation repeated twice or three times till the mercury is freed from the adhering air. When the section of the tubing is reduced to that of a capillary tube, the filling with mercury by this method is impracticable; this difficulty is overcome by the following modification.

The barometer tube, B, being filled with mercury in the usual way, is connected by a rubber tubing of from 6 to 8 cm. in length to a glass tube, open at both ends, of the same diameter and length as B; the tubes are placed in the position as shown in Fig. 1, and A filled with mercury. Care being taken that no air remains confined in the bend, C, and few taps should be given to the rubber tubing by the hand, or pressed by the finger of sufficient force to cause the emission of a few drops of mercury. By introduction of an air bubble into the tube, A, and partial closing of the orifice with the finger all air confined in the rubber bend is expelled by compression of the rubber. The compression being maintained for a few seconds, till a small portion of the mercury has been forced out and the tube hermetically closed, when the closed end is immersed in mercury and the finger withdrawn from the orifice, Fig. 2.

The following operation consists in the formation of a vacu-

um: By raising the barometer tube, B, Fig. 3, it then is lowered while A is moved in a nearly vertical position, Fig. 4, which causes a migration of the previously produced vacuum, $f m$, to the opposite portion, $f m^1$, of the tube. The exhaustion of the tube is repeated twice or three times, during which the tube is gently moved until the characteristic sound of the metal, on lowering and raising of the tube, becomes audible. After complete exhaustion, the tubes are disconnected, B is closed and immersed in mercury. The charging of A with mercury is effected by means of a small funnel, Fig. 1, and a complete exhaustion of the tubing is attained within twenty or thirty minutes.

The method is applicable to siphon and cistern barometer, and can also be used for the exhaustion of capillary tubing; the employment of an air pump and application of heat in exhausting the latter will greatly accelerate the operation. The manipulations which the method requires are simple; they can be performed with good results by persons unaccustomed to experimental work, always giving an excellent vacuum.

THE THERAPEUTICAL EFFECTS OF THE INTERNAL ADMINISTRATION OF HOT WATER IN THE TREATMENT OF NERVOUS DISEASES.*

By AMBROSE L. RANNEY, A. M., M. D., Professor of Applied Anatomy in the New York Post-Graduate Medical School and Hospital

A MUTUAL dependence may often exist between disordered states of the thoracic, abdominal, and pelvic viscera and some forms of functional disturbance of the nervous system. This is well recognized to-day by all neurologists.

The fact has been demonstrated, by a long array of clinical observations and physiological experiments, that the nerve-centers are not to be considered clinically as independent organs. The brain and spinal cord are to a certain extent but servants of the other viscera. On the other hand, the nerve-centers are occasionally the masters. They perform some of the functions (properly attributed to them in one sense) only in response to different forms of impressions conveyed to them from without. By means of vaso-motor and other varieties of nerve-filaments, sensory impressions made upon peripheral organs are now known to affect the general blood-pressure; to accelerate and arrest the action of the heart; to induce spasmodic and paralytic

disturbances in special physiological centers of the brain and spinal cord; to create localized phenomena of defective nutrition and assimilation; and to excite reflex nervous symptoms in parts far removed from the seat of peripheral irritation. We also know that the growth of the viscera, as well as their physiological functions, hangs upon a reciprocal relationship between them and the brain and spinal cord.

I mention these facts as a preface to my remarks this evening, because they will be shown to have a direct bearing upon a theory which I shall advance respecting the action of heat (when introduced into the stomach) upon the various organs and tissues.

The tendency of the age, particularly in neurology, seems to me to manifest itself in endeavors to discover new medicinal agents, often to the neglect of simple remedies whose influence upon the system has not yet been thoroughly tested. Among the latter, to my mind, hot water stands pre-eminently at the head.

It may seem a startling assertion, but it is nevertheless a fact, that more persons among the laity are to-day taking hot water for various ailments than any single drug in our Pharmacopoeia. In many instances they may be doing so injudiciously and without proper grounds; but that they are employing this agent, for actual or imaginary ills of the flesh, by thousands cannot be denied by any one acquainted with the facts.

The spread of the belief in the therapeutical value of hot water has traveled chiefly by word of mouth, as I know of only two articles in medical literature that have materially helped to popularize it. To employ hot water therapeutically could not have become so universal a custom unless great benefit had been bestowed by it upon many. My own experience with it in the treatment of nervous diseases has led me to call the attention of the profession again to its use as a therapeutical agent, and to point out some of the results that may be expected from it, and also how it should be administered.

In no work upon therapeutics or neurology have I been able to find any record of experiments made to determine either the physiological or therapeutical effects of hot-water drinking. In most of them no reference even is made to it as a remedy.

It was first employed in 1858, according to Dr. Cutter, by

*A paper read before the New York Academy of Medicine, October 16, 1884.

Dr. J. H. Salisbury, who made use of it in a series of experiments undertaken upon animals and men, with reference to the effects of food upon the animal economy as a cause and cure of disease. These experiments were commented upon by the London *Lancet* as a "valuable American contribution to medicine," according to Dr. Cutter, who gives no reference to the number of that journal.

In 1883 (June, 18) Dr. Ephraim Cutter published in *Gaillard's Medical Journal* a short article giving a summary of Dr. Salisbury's conclusions. The same article again appeared in the *Lancet* of September 15, 1883 (without any reference to its previous publication), although classed as an "original contribution" to that journal. Dr. Salisbury can perhaps lay just claim to originality. He tested this agent upon himself, selected subjects, and animals, and his experiments were presumably conducted upon an honest basis, and with scientific acumen.

I have never verified his experiments, because I have been unable to get a reply, either from him or from Dr. Cutter, to my written requests for a reference to the journal in which they were published originally, or in which they were reviewed. I have tested the accuracy of many of his conclusions, however (according to Dr. Cutter's statement of them), in a clinical way. I deem it therefore but justice to Dr. Salisbury, with whom I am personally unacquainted, to express here my indebtedness to the views which he was the first to advance. Not only have I communicated personally with Dr. Salisbury and Dr. Cutter, but our courteous librarian kindly offered to make diligent search for all articles upon this subject. Thus far he has been unable to find any, and all efforts by both of us to ascertain the date and channel of publication of Dr. Salisbury's original experiments have been fruitless.

Heat has been employed as a therapeutical measure in various ways for centuries. As a hæmostatic, hot water has lately become indispensable to the surgeon, although the red-hot iron was employed by Galen, and is still used to check hæmorrhage from bleeding mucous surfaces. As an antiphlogistic, heat is a household remedy. Who of us has not employed it in fever, inflammatory conditions, and many of the nervous disturbances of childhood that accompany these conditions?

Different temperatures are known to have widely different therapeutical effects:

1. Moderate heat, when applied to living tissues, causes a determination of blood to the part, with dilatation of its blood-vessels and an increased rapidity of the blood current. As examples of this action, I might cite the effects of the poultice upon suppuration, of the hot hip-bath and vaginal douches upon the catamenial discharges, of the hot bath upon the skin, and many others.

2. A higher degree of temperature, on the other hand, tends to cause contraction of the blood vessels and to diminish the amount of blood in the tissues; hence the action of very hot water as a hæmostatic.

3. Intense heat, as illustrated in the application of the actual cautery to the skin (so lightly even as to cause neither vesication nor pain), produces a very marked contraction in the blood-vessels of organs and tissues that lie adjacent to the part cauterized. It is believed to-day that this effect is produced through the agency of the vaso-motor system of nerves, and that the contraction of the blood-vessels is a direct result of the shock produced upon peripheral nerve-filaments by the intense heat employed.

We have clinical knowledge that the actual cautery will produce a return of the normal habit of sleep, after chronic cerebral hyperæmia has produced wakefulness for years, if employed at the upper part of the neck. It will relieve the symptoms of spinal congestion, as no other known remedy will. It will often produce secretion by the kidney if applied to the loins when congestion of that organ has led to complete suppression of urine. It will arrest neuralgic pains immediately in many cases. Finally, it will apparently exert an alterative change in tissues when persistently applied. In many forms of nervous diseases, this method of employing heat is recognized as an important aid in treatment. The cautery apparatus is to-day one of the most valuable additions to the neurologist's outfit. It is almost indispensable in the treatment of nervous diseases.

The benefits that result from the internal use of hot water, to which I shall call attention, must be due, in part at least if not wholly, to heat. Some of its effects are manifested, almost immediately, in organs not connected directly with the digestive apparatus. I will suggest further on in this article a theoretical explanation of these effects, based upon anatomical data relating to the nervous system.

RULES FOR ADMINISTRATION.

Let me state first, however, the method which should be rigorously followed in taking hot water for its remedial effects.

1. The water may be taken in doses of from one goblet to one and a half. An ordinary goblet contains about ten ounces. The dose must be modified in accordance with its effects.

2. It must be drunk hot, and not warm (110 to 150 degrees). If necessary, fifteen minutes or more may be consumed in sipping a gobletful. Wooden cups prevent the water from cooling quickly. The water may be flavored with lemon, sugar, salt, ginger, etc., if necessary,* but it becomes very agreeable to the palate without such after the patient has taken it for a short time.

3. The dose must be taken one hour and a half before each meal with absolute punctuality, and one at bed-time. My patients have the first dose brought to their bed-side, and consume it before rising. The passage of the fluid into the intestine, or its absorption before the meal, is insured by this rule. The quantity taken daily must be modified according to the effects produced.

4. The temperature of the water should be increased as fast as the patients can bear it. It is remarkable how high a degree of heat some patients can endure after taking hot water for months. At first, such a temperature would blister the mouth. Below 110 degrees, the heat is not sufficient, as a rule, to have any therapeutical effects, save as an emetic.

5. The administration of hot water must be continued for at least six months, in order to get its full effects. It will be some weeks, as a rule, before any beneficial effects become markedly apparent. It is not sufficient for a test of its value that it be given at irregular intervals, with variable degrees of temperature, and with no regard for the specific gravity of the urine and the proportion of solid ingredients secreted by the kidney.

6. The dose should be determined largely by the specific

gravity and general character of the urine. If it falls as low as 1.010, the dose should be reduced, if necessary, to one half a pint. If it reaches 1.030, the dose should be gradually increased to a pint, provided that the daily quantity of urine has not been decreased to a point below the normal standard by profuse sweating. The average urinary secretion of a healthy adult should vary between thirty-five and fifty ounces for twenty-four hours. It may occasionally reach two quarts. The object of the treatment should be to bring the specific gravity of the urine to the standard of health, 1.010-1.023, and to keep it there.

7. The use of cold fluids, in the form of beverages, must be absolutely prohibited. Many patients have told me, after following this treatment, that they will never from preference drink cold water again.

8. A restricted diet is often necessary to the full effects of the treatment, in some forms of nervous derangements. It is my custom with some patients to forbid all sweets, pastry, fresh bread in any form, and fats. In other instances I employ the meat diet exclusively, the fatty parts being removed before cooking. The sour wines are not usually forbidden, nor is tea or coffee, unless they are apparently injurious to the patient. The condition of the subject, in respect to flesh, is my guide, as a rule, to the character of the diet prescribed, provided that marked disturbances to digestion or diabetic symptoms are not to be combated. If the patient is ill-proportioned as regards adipose tissue, I aim to reduce the weight gradually to the normal standard. This is estimated on the basis of the height, sex, bony framework, etc. Cutting down the saccharine and starchy elements of food will effect this reduction in weight rapidly. If the subject is thin and poorly nourished, I adopt the opposite plan, often with good results.

THE EFFECTS OF THE TREATMENT.

1. On drinking a goblet of hot water for the first time, a sense of warmth within the stomach will be produced, unaccompanied with nausea. This is not the case with warm water, since emesis often follows its introduction into the stomach. Hot water increases downward peristalsis; warm water reverses peristalsis and induces vomiting. Eructations of gas from the stomach commonly occur within a few minutes after the first dose of hot water. This effect may persist for some weeks. Excessive eructation indicates that fermentation of food occurs after eating, from defective alimention.

2. The skin soon shows the effect of the heat. A gentle glow with a tendency to perspiration is developed rapidly. This is diffused over the entire body. Coldness of the extremities is often very much benefited, and in a short time, by this treatment. The circulation of the body appears to become more uniform. It is rational to suppose that the viscera are often thus relieved of engorgement, and aided in the performance of their proper functions. Perspiration so induced is unquestionably associated with an increased supply of blood to the skin, since it is accompanied with a sensation of increased warmth.

3. The kidneys exhibit marked effects of this treatment early. Almost immediately, the quantity of urine is increased. It is usually improved also in its proportion of solid ingredients, provided the organs are inclined to be sluggish. If, on the other hand, diabetic symptoms exist, the specific gravity is frequently modified and the quantity reduced. One patient, who was lately placed under my care with marked saccharine diabetes and symptoms of cerebral hyperæmia of a severe type, has been perfectly cured by hot water, restricted diet, and simple tonics. He had previously tried all the known remedies (and a diabetic diet as well) for years without benefit. I was called in consultation about a year ago in a similar case, and the patient recovered under this treatment. He had symptoms of an alarming character, and had previously found no relief. Both of these cases were, in my opinion, of neurotic origin. The head symptoms, which were very marked in both, disappeared under the same treatment, although the actual cautery had been tried thoroughly, and had failed to arrest them.

4. The accessory organs of digestion (the liver and pancreas) seem to be stimulated by the internal use of hot water. Gradually, under its continued use, the bowels move regularly, and the feces eventually become soft and yellow in color.* Flatulence and constipation are enumerated as things of the past. I have known hemorrhoids of long standing to disappear under this treatment. Chronic diarrhoea was thus arrested by me in one instance. It was apparently due to extreme nervous debility.

5. The nervous system seems to be profoundly impressed by a prolonged use of this agent. Especially is this the case among that class of patients who suffer from the effects of hyperæmia and anæmia of the brain and of the spinal cord and spinal nerves. Perhaps there are no greater sufferers than are found among this class. I have at present under my care a lady who for twenty years has been confined almost constantly to her house from neuralgic attacks which have withstood all medicinal agents. Under the use of hot water and the meat diet (she is somewhat fleshy), the symptoms have shown a marvelous improvement within one month. Her paroxysms are already very much diminished in their severity, and are comparatively infrequent. I hope to see them disappear entirely.

I have at present under my charge several patients suffering from locomotor ataxia. I am treating them by the internal administration of hot water, in conjunction with the actual cautery, nitrate of silver, and the iodide of potash. Sufficient time has not yet elapsed, since the hot water was prescribed, to state positively that permanent benefit has been derived from it, but I am convinced that very marked improvement has followed its use in two cases. It is my intention to publish subsequently the records of all of these experiments. Thus far the efforts of neurologists to arrest progressive sclerosis of the posterior columns of the spinal cord have been unsatisfactory, and the question of a direct dependence of this condition upon the syphilitic taint must probably (to my mind) be decided in the negative.† Pathological research to date has not aided us in determining its etiology; hence its treatment, as yet, is purely empirical, and experimentation regarding its cure is particularly to be desired. I can only say in this connection that one patient, whom I have at present under observation, came to me unable to walk, save by the aid of two canes and a body servant. Already one cane and the servant have been dispensed with, and the patient suffers less than he did from

* The first of the feces are made very black by the washing down of the bile.

† The statistics upon which syphilis has been classed among the etiological factors of ataxia are open to severe criticism. Our present knowledge of the morbid changes produced by syphilis upon the cerebro-spinal axis does not appear to sustain the view that systematic lesions of the cord are ever directly produced by it.

anæsthesia of the limbs and lightning pains. Another, who had diplopia, and marked inco-ordination of movement, is no longer troubled with imperfect vision, and walks with more confidence. I am aware that similar results have been recorded without recourse to the hot water treatment, but in these cases it seems to have been a marked factor in the amelioration of the symptoms. If it could be proved that this agent exerts a remedial influence upon gray degeneration of the spinal cord, what a boon would be conferred upon thousands who are now suffering without much hope of cure!

The paucity of literature upon this therapeutical agent renders statistics collected from the experience of others impossible.

This paper is necessarily but a record of my own experience. I may be pardoned for apparent egotism, therefore, if I refer here only to cases which have been intrusted to my care.

Within the past five years I have succeeded in curing three cases of gastralgia, where the paroxysms have been frequent and terribly severe for a long time. In one of these (that of a gentleman of great will and courage) the severity of the pain would frequently cause fainting. In another (that of a lady of forty-five years of age) the gastric pain had been constant for years, and gastric cancer had been suspected to exist.

Patients with neurasthenia are almost invariably benefited by the hot water treatment. In many instances I have witnessed a rapid disappearance of all the abnormal nervous phenomena. Two cases of focal anæmia of the brain, with transient aphasia, have been lately observed by me. Both patients recovered under the hot water treatment and tonics. The latter had been tried alone in one of them, for some premonitory symptoms, without marked benefit.

To cite all of the cases in which I have employed this agent, either alone or in combination with other methods of treatment, would exceed the limits of this article. I believe, however, from my observations to date, that the use of hot water will prove of great value in neurasthenia and some of the functional nervous derangements.

My observations of its effects upon epilepsy and chorea are as yet imperfect, and therefore lead me to no positive conclusions.

I think it not impossible, moreover, that the continued use of this therapeutical adjunct may tend to modify, if not arrest, some of the progressive degenerations of the cord. I am not prepared to make any assertion to that effect, however, although I am testing it in some aggravated cases, in connection with the use of the cautery and medicinal agents. This field has been previously referred to.

THEORY OF ITS ACTION.

It is a temptation to speculate in regard to the probable channels through which the effects of hot water upon the system are exerted. To my mind, the neurotic theory is the most plausible. I believe that the nerves of the stomach, and possibly the solar plexus (the ramifications and connections of which with the central nerve centers are not fully determined), are directly influenced by the heat introduced into the empty organ.

Mayer and Pribram have already shown that electrical and mechanical irritation of the walls of the stomach can produce a reflex contraction of the cerebral vessels. Kussmaul has demonstrated that similar effects may follow faradization of the cervical sympathetic. Notbuegel and Loven have proved that irritation of peripheral nerves exerts a marked effect upon the arteries.

The solar plexus lies immediately behind the stomach, and is connected with all the abdominal viscera. The splanchnic nerves of either side, and probably the terminal filaments of the right pneumogastric nerve, enter into its formation. It is therefore connected directly with the brain and the main sympathetic cords, and indirectly with all of the organs of the body. It is the most important of all the sympathetic plexuses, as well as the largest. Why are we not justified in believing that the effect of stimulation of this plexus, by heat through the stomach, will accomplish that which electrical stimulation of the stomach itself has been proved to attain? Are we not warranted in attributing the warmth of the skin, the perspiration, the increased activity of the kidney, the stimulation of downward peristalsis, and the other effects of this agent, to a remote influence upon the vaso-motor nerves or their centers? If so, why is the view irrational that cerebral and spinal hyperæmia and anæmia may be controlled and brought to the normal standard by the same means?

POINTS IN ITS FAVOR.

This method of treatment has certainly one thing in its favor that few possess, viz., it is harmless. Because its remedial effects are slow in some cases, it is no proof that they are not doubly permanent. Are we not convinced daily that many of the more common nervous diseases are obscure in their origin, and that the removal of the cause might hasten recovery, if we could only detect it?

Most of our nationality chill their stomachs with ice-water between meals and during the act of eating. Who would think of feeding a horse, and placing a bucket of ice water by his side? The question may well be raised if this one habit alone has not done more harm to the nervous systems of men than tobacco or alcohol, the use of which is mentioned in all text-books as an etiological factor in nervous diseases.

I believe that the success of the hot mineral waters, as consumed at the famous springs of this country and Europe, for chronic diseases, depends more upon the employment of internal heat as a therapeutical agent than upon the mineral ingredients of the waters themselves. I do not advance this view to disparage the medicinal qualities of these waters, but to bring into prominence the view that heat, restricted diet, and enforced mental and physical rest are probable factors in the remarkable cures that are brought about by their use.

In anticipation of argument, I might say that I am well aware that this agent is not a new one, and that it is not always followed by the effects enumerated. Who of us, however, has not met in professional experience cases where opium has failed to produce sleep? Yet who doubts that it is one of our chief hypnotics? I lately encountered a case where sixty grains of morphine were consumed daily, by the mouth, and constipation had never existed. Yet who would dispute the statement that this drug tends, as a rule, to restrain the free action of the bowel, even in small doses? Because the public are to-day crazed over hot water drinking, and are asserting for it medicinal virtues to which it has no title, are we justified in denying for it a fair trial in those diseased conditions that withstand the routine medicinal treatment recommended by text-books? We have un-

* Cinnamon, clover tea blossoms, sage, aromatic spirits of ammonia, and sulphate of magnesium have also been suggested. I often introduce a teaspoonful of carbolic acid into the morning dose, to relieve constipation, when it is obstinate.

doubtedly yet to learn exactly to what extent it exerts a remedial influence upon the kidneys, digestive organs, vascular apparatus, skin, and the principal nerve-centers, but that it is potent in some cases cannot be disputed. *No pretension is made for it here as a panacea.*

Again, it may be argued that, in some of the cases to which I refer, this agent has been employed in conjunction with restricted diet, the actual cautery, the internal administration of tonics, etc.; and that some of the benefits may justly be attributed to these factors in the treatment. To this criticism I would reply that in some of these cases, the hot water has not been used until the other agents spoken of had been thoroughly tried, and that improvement has been markedly hastened by adding it to the previous treatment. In one diabetic case reported, the symptoms were not controlled by drugs or restricted diet; but the excretion of sugar ceased in a few weeks, when hot water was ordered as an adjunct to a diet from which all starchy and saccharine foods were expunged.

A third class of critics, whom I as well as most of those present have often encountered in argument, are those who expect immediate results, and who throw every agent overboard in case they fail to get results as promptly as they had expected. They argue that patients will not take any form of treatment with regularity which does not show rapid results. Admitting, for the sake of argument (and on no other ground), that there may be a shadow of truth in this statement, I would reply that (provided the patient is prepared at the first visit for slow results, and informed in respect to its action) this objection can be overcome. I would suggest, furthermore, that the use of hot water does not preclude the employment of opiates and other drugs, when the exigencies of the case seem to demand them. One reason why this agent may not be productive of good results, even in favorable cases, is that it is not given systematically and in accordance with the rules previously suggested. Hot water is unquestionably not conducive to health if poured into the stomach without restrictions as to quantity and the proper time for its administration.

CONCLUSIONS.

In summary, I would urge a thorough trial of this therapeutic agent by the profession, on the following grounds:

1. It is harmless if properly administered. A degree of temperature that can be endured by the mouth will not impair the integrity of the stomach. Absurd as it may seem, I have heard this argument used by men of intelligence with every appearance of sincerity. Many of us drink coffee and tea at an equally high temperature, and in as large quantities as are compatible with the hot water treatment.

2. Its effects are comparatively uniform, provided it be given for a sufficient period. Exceptions prove a rule. Isolated cases may be occasionally encountered where the results as stated do not occur.

3. It seems to exert a curative influence upon many of the chronic diseases that influence and disturb the proper assimilation of food. Some of these are important factors in the development of nervous derangements. I restrict my statements for hot water as yet chiefly to the cure of these diseases, because I have not scientific data upon which to base a broader statement. Subsequent investigation can alone decide as to what limits the remedial use of this agent should be restricted.

4. It appears that the curative influence of hot water is not usually transient. In many of my cases the symptoms have shown no tendency to return when once checked by its use, provided that the patient's indiscretions do not lead to a relapse.

5. It may be employed as an adjunct to all recognized methods of treatment, without detriment to the patient.

6. It exerts a marked influence upon vascular disturbances of the nerve centers. Especially is this the case, in my experience, with those subjects that suffer from cerebral hyperemia and anemia. I have seen some remarkable results follow the protracted use of the hot water treatment in headache, vertigo, neuralgia, insomnia, and other conditions produced by vascular disturbances.

7. In diabetes and in some kidney derangements, I have seen the most happy effects follow the internal administration of hot water. Its action as a diuretic is quite remarkable in some cases. It seems also to influence the secretion of urinary salts, since the specific gravity of the urine is my guide in regulating the quantity of hot water for daily consumption.

8. As a laxative, hot water has a slow but decided action. The feces are at first rendered black, from an excess of bile, but they gradually change to a yellow color, and become more like that of the infant. It seems to be a justifiable deduction, therefore, that the functions of the accessory organs of digestion are made active by its use and brought to the standard of health.

9. The skin is stimulated by the use of this agent, and the cutaneous circulation is apparently rendered more uniform. I have seen the hue of the skin in disease altered by it, and eruptions of a chronic character markedly benefited.

10. From a few experiments which I have made with reference to the effect of this agent as a preventive of sea sickness, I am led to believe that it should be employed for from four to six weeks preceding an ocean voyage, in accordance with the rules given earlier in the evening.

In conclusion, I would state that, if I had been led to express views that may appear extreme to many, it is because my convictions are based upon clinical observations of no inconsiderable magnitude. I have seen my previous failures in treatment turned by this agent into brilliant successes in some instances. In others, symptoms have been ameliorated by the use of hot water more rapidly than by methods of treatment universally recommended by text-books. To what limits the value of this agent will be restricted, as a therapeutic adjunct, the results of collected observation and experience to date cannot fully determine. I shall await with interest the published results of the experience of others, who have doubtless employed this agent in various forms of chronic diseases, and especially those bearing upon the department of neurological medicine.—*N. Y. Medical Journal.*

TO PRESERVE EGGS.—According to *Mittheilungen über Landwirthechaft*, etc., vaseline is a good preservative for eggs. The eggs should be thoroughly washed, and rubbed in the vaseline previously melted with 3-10 per cent. of salicylic acid. The operation should be performed twice, the latter one month after the former. On boiling, the skin of vaseline easily separates from the eggs. Eggs thus treated are said to keep perfectly fresh for a year.

ON CATAGENESIS.*

By E. D. COPE.

I. THE EVOLUTION OF ORGANISMS.

THE general proposition that life has preceded organization in the order of time may be regarded as established. It follows necessarily from the fact which has been derived from paleontological investigation, that the simple forms have, with few sporadic exceptions, preceded the complex in the order of appearance on the earth. The history of the lowest and simplest animals will never be known on account of their perishability; but it is a safe inference from what is known, that the earliest forms of life were the rhizopods, whose organization is not even cellular, and includes no organs whatever. Yet these creatures are alive, and authors familiar with them agree that they display, among their vital qualities, evidences of some degree of sensibility.

The following propositions were laid down by Lamarck, as established by facts known to him, in 1809:†

1. "In every animal which has not passed the term of its development, the frequent and sustained employment of an organ, gradually strengthening it, develops and enlarges it, and gives it power proportional to the duration of its use; while the constant disuse of a like organ insensibly weakens it, deteriorates it, progressively reduces its functions, and finally causes it to disappear.

2. "All that nature acquires or loses in individuals, through the influence of circumstances to which the race has been exposed for a long time, either by the predominant use of an organ or by the disuse of such part, she preserves by generation among new individuals which spring from it, provided the acquired changes be common to both sexes or to those which produce new individuals."

The same proposition was previously enunciated by Lamarck in the following condensed form (*Recherches sur les corps vivans*, p. 50):

"It is not the organ, that is, the nature and form of the parts of the body, which have given origin to its habits and peculiar functions, but it is, on the contrary, its habits, its manner of life, and the circumstances in which individuals from which it came found themselves, which have, after a time, constituted the form of the body, the number and character of its organs, and the functions which it possesses."

Several years ago, not having read Lamarck, I characterized the above hypothesis as the "law of use and effort,"‡ and I have subsequently formulated the *modus operandi* of this law into two propositions. The first of these is, that animal structures have been produced, directly or indirectly, by animal movements, or the doctrine of *kinetogenesis*; the second is, that as animal movements are primitively determined by sensibility, or consciousness, that consciousness has been, and is, one of the primary factors in the evolution of animal forms. This is the doctrine of *archæsthetism*. The doctrine of *kinetogenesis* is implied in the speculations of Lamarck in the following language (*Philosophie Zoologique*, ed. 1830, p. 239): "With regard to the circumstances which [nature] uses every day to vary that which she produces, one can say that they are inexhaustible. The principal arise from the influence of climates; from diverse temperatures of the atmosphere and of the environment generally; from diversity of location; from habits, the most ordinary movements, and most frequent actions," etc. The influence of motion on development is involved in Spencer's theory of the origin of vertebræ by strains;§ and I have maintained the view that the various agencies in producing change mentioned by Lamarck are in the case of animals simply stimuli to motion.¶ The immediate mechanical effect of motion on animal structure has been discussed in papers by Ryder, Hyatt, Clevenger, and myself, and I have cited the evidence of vertebrate paleontology as conclusively proving such an effect.¶

The object of the present paper is to pursue the question of the relation of sensibility to evolution, and to consider some of the consequences which it involves. It is scarcely necessary to observe that in the early stage which the subject presents at the present time, I can only point out the logical conclusions derivable from facts well established rather than any experimental discoveries not already known. And I will say here to those who object to the introduction of metaphysics into biology, that they cannot logically exclude the subject. As in one sense a function of nervous tissue, mind is one of the functions of the body. Its phenomena are everywhere present in the animal kingdom. Moreover, when studied in the inductive, a *posteriori* method, metaphysics is an exact science. As Bain observes, it is a good deal easier to tell the action of a man than those of the weather. It is only want of familiarity with the subject which can induce a biologist to exclude the science of mind from the field.

For the benefit of those who are not familiar with the doctrine of *archæsthetism*,** I give an outline of its implications. In the first place, the hypothesis that consciousness had played a leading part in evolution would seem to be negated by the well known facts of reflex action, automatism, etc., where acts are often unconsciously performed, and often performed in direct opposition to present stimuli. But while it is well understood that these phenomena are functions of organized structure, it is believed that the habits which they represent were inaugurated through the immediate agency of consciousness. It is not believed that a designed act can have been performed for the first time†† without consciousness, on the part of the animal, of the want which the act was designed to relieve or supply. This opinion accords with our knowledge of ourselves and, by irresistible inference, with our belief regarding other animals. From such familiar observation we also know that, so soon as a movement of body or mind has been acquired by repetition, consciousness need no longer accompany the act. The act is said to be automatic when performed without exertion, either consciously or unconsciously, and in those functions now removed from the influence of the unconscious mind, such acts are called reflex. The origin of the acts is, however, believed to have been in consciousness, not only for the reasons above stated, but also from facts of still wider application. The hypothesis of *archæsthetism* then maintains that consciousness as well as

life preceded organism, and has been the *primum mobile* in the creation of organic structure. This conclusion also flows from a due consideration of the nature of life. I think it possible to show that the true definition of life is, *energy directed by sensibility, or by a mechanism which has originated under the direction of sensibility*. If this be true, the two statements that life has preceded organism, and that consciousness has preceded organism, are coequal expressions.

II. CONSCIOUSNESS, ENERGY, AND MATTER.

Regarding for the time being the phenomena of life as energy primitively determined by consciousness, let us look more closely into the characteristics of this remarkable attribute. That consciousness, and therefore mind, is a property of matter is a necessary truth, which to some minds seems difficult of acceptance. That it is not an attribute of all kinds of matter is clear enough, but to say that it is not an attribute of any kind of matter is to utter an unthinkable proposition. To my mind the absence of tridimensional matter is synonymous with nothingness, or absolute vacuity. To say that phenomena have a material basis, is for me only another way of saying that they exist. It being granted then that consciousness is an attribute of matter, or a certain behavior of matter, it remains to trace its relation to energy, which is here used in the sense of motion. Consciousness is clearly not one of the known so-called inorganic forces. Objects which are hot, or luminous, or sonorous, are not, as is well known, on that account conscious. Consciousness is not then a necessary condition of energy. On the other hand, in order to be conscious, bodies must possess a suitable temperature, and must be suitably nourished. So energy is a necessary condition of consciousness. For this reason some thinkers regard consciousness as a form or species of energy. For my own part, in classification, I prefer to keep very different things apart. To classify consciousness with heat, light, sound, etc., does violence to my sense of fitness and to all proper definitions. This is well shown by Professor Clifford in the following passage:

"It will be found excellent practice in the mental operations required by this doctrine, to imagine a train the forepart of which is an engine and three carriages linked with iron couplings, and the hind part three other carriages linked with iron couplings; the bond between the two parts being made out of the sentiments of amity subsisting between the stoker and the guard."

This satire, whether intentionally or not on the part of its learned author, expresses at once the distinctive character of consciousness *in esse* and the impossibility of dissociating it from energy *in posse*. For it is sufficiently clear that while the conscious feelings of the stoker and the guard could by themselves do nothing for the train, such a state is essential to the energy displayed by them when they are at work for its benefit. We all understand the absurdity of such expressions as the equivalency of force and matter, or the conversion of matter into force. They are not, however, more absurd than the corresponding proposition, more frequently heard, that consciousness can be converted into energy, and *vice versa*.

The energetic side of consciousness, however, may be readily perceived by a little attention to its operations. Acts performed in consciousness involve a greater expenditure of energy than the same acts unconsciously performed. The difficulty of a given piece of labor is in direct proportion to its novelty; that is, is in direct proportion to the amount of endeavor we use in its performance. This is another way of saying that the labor is directly as the consciousness involved. Another evidence of the dynamic character of consciousness is its exclusive and therefore complementary character. Two opposite emotions cannot occupy the mind at the same moment of time. An emotion excludes all high intellectual work, and *vice versa*.

But there is no fact with which we are more familiar than that consciousness in some way determines the direction of the energy which it characterizes. The stimuli which affect the movements of animals at first only produce their results by transmission through the intermediation of consciousness. Without consciousness, education, habits, and designed movements would be impossible. So far as we know, the instinct of hunger, which is at the foundation of animal being, is a state of consciousness in all animals. This incontestable fact is overlooked by the materialists properly so called.

On the other hand, as consciousness is an attribute of matter, it is of course subject to the laws of necessity to which matter and energy conform. For instance, it cannot cause two solid bodies to occupy the same space at the same time, nor can it add one body to one body, and thus make three bodies. No more can it make ten foot-pounds of energy out of five foot-pounds of energy, and it cannot abolish time more than it can annihilate space. These are fundamental truths which are overlooked by a majority of mankind. Moreover, nothing is more common than to hear life or mind spoken of as though it of itself is a "substance," and not as it should be as an attribute or condition of substance or matter.

What is then the immediate action of consciousness in directing energy into one channel rather than another? To take an illustration: Why, from a purely mechanical point of view, is the adductor muscle of the right side of the horse's tail contracted to brush away the stinging fly from the right side of the horse's body, rather than the left adductor muscle? Why was the contraction provoking energy deflected into the right interspersal motor nerves rather than into those of the left side? Why is the ear of the horse turned forward to catch the sound in front of him, and backward to gather the sound coming from behind? The first crude thought is, that consciousness supplies another energy which turns aside the course of the energy required to produce the muscular contraction; either as the man with the rein in his hand turns aside the horse's head or as the shield he holds deflects a moving body. But consciousness, *per se*, that is, regarding it in its proper and distinctive definition, is not itself a force (= energy). How then can it exercise energy? Certainly no more than the bare good will of the train hands can pull the train. Such an explanation is to admit the possibility of making something out of nothing.

III. THE RETROGRADE METAMORPHOSIS OF ENERGY.

The key to many weighty and mysterious phenomena lies in the explanation of the so-called voluntary movements of animals. I say "so-called," because true will is not at all involved in the question. I mean the acts directed by consciousness, the acts which would not take place at all if the animal were unconscious. That there are many such acts you well know. The explanation can only be found in a simple acceptance of the fact, as it is in the thesis, that *energy can be conscious*. If true, this is an ultimate fact, neither more

* An address delivered before the Biological Section of the American Association for the Advancement of Science, at Philadelphia, September 4, 1884, by E. D. Cope, Vice-President.

† *Philosophie Zoologique*, pt. I, p. 235 (ed. 1830).

‡ Method of Creation, Proceedings American Philosophical Society, 1871, p. 247.

§ Principles of Biology, ii, p. 195.

¶ On the Relation of Animal Motion to Animal Evolution, *American Naturalist*, Jan., 1878.

¶ The Evidence for Evolution in the History of the Extinct Mammals, *Am. Ass. Adv. Sci.*, 1883, p. 33.

** *American Naturalist*, 1882, p. 454.

†† The same view is expressed by Ribot, *Diseases of the Will*, p. 38 (Humboldt Libr.).

nor less difficult to comprehend than the nature of energy or matter in their ultimate analyses. But how is such a hypothesis to be reconciled with the facts of nature, where consciousness plays a part so infinitesimally small? The explanation lies close at hand, and has already been referred to. *Energy become automatic is no longer conscious*, or is about to become unconscious. That this is the case is matter of everyday observation on ourselves and on other animals. What the molecular conditions of consciousness are, is one of the problems of the future, and for us a very interesting one. One thing is certain, the organization of the mechanism of habits is its enemy. *It is clear that in animals, energy, or the loss of consciousness, undergoes a retrograde metamorphosis*, as it does later in the history of organized beings on their death. This loss of consciousness is first succeeded by the so-called involuntary and automatic functions of animals. According to the law of catagenesis, the vegetative and other vital functions of animals and plants are a later product of the retrograde metamorphosis of energy. With death, energy falls to the level of the polar tensions of chemistry, and the regular and symmetrical movements of molecules in the crystallization of its inorganic products. Let us now trace in more detail the energies displayed by animals and plants.

It has been already advanced that the phenomena of growth force, which are especially characteristic of living things, originated in the direction given to nutrition by consciousness and by the automatic movements derived from it. There remain, however, some other phenomena which do not yield so readily to this analysis. These are:

1. The conversion by animals of dead into living protoplasm.
2. The conversion of inorganic substances into protoplasm by plants.
3. The manufacture of the so-called organic compounds from the inorganic by plants.

To these points we may return again. It is also well known that living animal organisms act as producers, by conversion of various kinds of inorganic energy, as heat, light, sound, electricity, motion, etc. It is the uses to which these forces are put by the animal organism, the evident design in the occasion of their production, that gives them the stamp of organic life. We recognize the specific utility of the secretions of the glands, the appropriate distribution of the products of digestion, and adaptation of muscular motion to many uses. The increase of heat to protect against depression of temperature; the light to direct the sexes to each other; the electricity as a defense against enemies; display unmistakably the same utility. We must not only believe that these functions of animals were originally used by them, under stimulus for their benefit, but if life preceded organism, that the molar mechanism which does the work, has developed as the result of the animal's exertions under stimuli. This will especially apply to the mechanism for the production of motion and sound. Heat, light, chemistry, and electricity doubtless result from molecular aptitudes inherent in the constitution of protoplasm. But the first and last production of even these phenomena is dependent on the motions of the animal in obtaining and assimilating nutrition. For without nutrition all energy would speedily cease. Now the motion required for the obtaining of nutrition has its origin in the sensation of hunger. So even for the first steps necessary to the production of inorganic forces in animals, we are brought back to a primitive consciousness.

To regard consciousness as the primitive condition of energy, contemplates an order of evolution in large degree the reverse of the one which is ordinarily entertained. The usual view is, that life is a derivative from inorganic energies as a result of high or complex molecular organization, and that consciousness (=sensibility) is the ultimate outcome of the nervous or equivalent energy possessed by living bodies. The failure of the attempts to demonstrate spontaneous generation will prove, if continued, fatal to this theory. Nevertheless, the order cannot be absolutely reversed. Such a proceeding is negated by the facts of the necessary dependence of the animal kingdom on the vegetable, and the vegetable on the inorganic for nutrition, and consequently for existence. So the animal organism could not have existed prior to the vegetable, nor the vegetable prior to the mineral. The explanation is found in the wide application of the "doctrine of the unspecialized,"* so clearly demonstrated by palæontology. From this point of view creation consists in specialization, an expression which describes the specific action of the general principle described by Spencer as the conversion of the homogeneous into the heterogeneous. To be more explicit, it consists of the production of mechanism out of no mechanism, of different kinds of energy out of one kind of energy. The material basis of consciousness must then be a generalized substance which does not display the more automatic and the polar forms of energy. From a physical standpoint protoplasm is such a substance. Its instability indicates weakness of chemical energy also, which suggests that the complexity of its molecule may be due to some form of energy not properly chemical. The readiness with which it undergoes retrograde metamorphosis shows that it is not self-sustaining, and furnishes a good illustration of creation of specialized substances by a running down in the scale of being. Loew and Bokorny† suggest that "the cause of the living movements in protoplasm is to be sought for in the intense atomic movements, and therefore easy metamorphosis of its aldehyde groups of components;" the molecular movements becoming molar, to use the language of Lester Ward. The position which I now present requires the reversal of the relations of these phenomena. Generalized matter must be supposed to be capable of more varied molecular movements than specialized matter, and it is believed that the most intense of all such movements are those of brain tissue in mental action, which are furthest removed of all from molar movements. From this point of view, when molar movements are derived from molecular movements, it is by a process of running down of energy, not of elevation; by an increase of the distance from mental energy, not an approximation to it.

The fact that the physical basis of consciousness is composed of four substances, which are respectively a monad, a dyad, a triad, and a tetrad, doubtless has something to do, as I have suggested,‡ with its exhibition of this remarkable attribute. It might be supposed that the presence of carbon had the effect of restraining the chemical and physical molecular tendencies of the three other substances. From this standing-ground we may imagine that other substances besides protoplasm might support consciousness and life. In

other parts of the universe, other substances they would have to be, if consciousness exist there.

The manner in which protoplasm is made at the present time is highly suggestive. It is manufactured by living plants out of inorganic matter, the hydrogen, carbon, nitrogen, and oxygen contained in the atmosphere and in the earth. As dead plants will not perform this function, this action is regarded as in some way due to the presence of life. The energy peculiar to living protoplasm, and derived primarily in part only from the sun's rays, directs energy so that the complex molecular aggregation protoplasm is the result. This is the only known method of manufacture from inorganic matter of this substance. The first piece of protoplasm had however no paternal protoplasm from which to derive its being. The protoplasm-producing energy must, therefore, have previously existed in some form of matter not protoplasm. This is also suggested by the fact that it really antagonizes the chemical forces, and might be called, from this fact, *antichemism*. The protoplasm-sustaining energy of animal protoplasm may be a less energetic derivative, or *vice versa*. In terms of the theory of catagenesis, the plant life is a derivative of the primitive life, and it has retained enough of the primitive quality of self-maintenance to prevent it from running down into forms of energy which are below the life level; that is, such as are of the inorganic chemical type, or the crystalline physical type. A part of the energy does so run down, as can be seen in the few automatic movements of plants, and the phosphorescence of some. Also symmetrical crystals are made by some. But M. Pasteur has shown* that whenever the crystals are of the organic type, i. e., contain carbon, they are not symmetrical but are unilateral, or, as he terms them, dissymmetrical. This indicates that the presence of carbon has restrained, a little, the absolute symmetrical automatism of the formative force.

IV. ORIGIN OF LIFE ON THE EARTH.

If then some form of matter other than protoplasm has been capable of sustaining the essential energy of life, it remains for future research to detect it, and to ascertain whether it has long existed as part of the earth's material substance or not. The heat of the earlier stages of our planet may have forbidden its presence, or it may not. If it were excluded from the earth in its first stages, we may recognize the validity of Sir William Thomson's suggestion that the physical basis of life may have reached us from some other region of the cosmos by transportation on a meteorite. If protoplasm in any form were essential to the introduction of life on our planet, this hypothesis becomes a necessary truth. Here let me refer to the fact that hydrocarbonaceous substances have been discovered in meteorites. Here also the remarkable discovery of Huggins claims attention.† This veteran spectroscopist has detected the lines of some hydrocarbon vapor in the spectra of interplanetary spaces. The significance of this discovery is at once perceived if we believe that hydrocarbons are only produced under the direction of life‡.

Granting the existence of living protoplasm on the earth, there is little doubt that we have some of its earliest forms still with us. From these simplest of living beings both vegetable and animal kingdoms have been derived. But how was the distinction between the two lines of development, now so widely divergent, originally produced? The process is not difficult to imagine. The original plastid dissolved the salts of the earth and appropriated the gases of the atmosphere and built for itself more protoplasm. Its energy was sufficient to overcome the chemistry that binds the molecules of nitrogen and hydrogen in ammonia, and of carbon and oxygen in carbonic dioxide. It apparently communicated to these molecules its own method of being, and raised the type of energy from the polar non-vital to the adaptive vital by the process. Thus it transformed the dead mineral world, perhaps by a process, of invasion, as when a fire communicates itself from burning to not burning combustible material. Thus it has been doing ever since, but it has redeposited some of its gathered stores in various non-vital forms. Some of these are in organic forms, as cellulose; others are crystals imprisoned in its cells; while others are amorphous, as waxes, resins, and oils. But consciousness apparently early abandoned the vegetable line. Doubtless all the energies of vegetable protoplasm soon became automatic. The plants in general, in the persons of their protist ancestors, soon left a free-swimming life, and became sessile. Their lives thus became parasitic, more automatic, and in one sense degenerate.

The animal line may have originated in this wise: Some individual protists, perhaps accidentally, devoured some of their fellows. The easy nutrition which ensued was probably pleasurable, and once enjoyed was repeated, and soon became a habit. The excess of energy thus saved from the laborious process of making protoplasm was available as the vehicle of an extended consciousness. From that day to this, consciousness has abandoned few if any members of the animal kingdom. In many of them it has specialized into more or less mind. Organization to subserve its needs has achieved a multifarious development. There is abundant evidence to show that the permanent and the successful forms have ever been those in which motion and sensibility have been preserved, and most highly developed.

This review of the history of living organisms has been epitomized in the following language:§ "Evolution of living types is then a succession of elevation of platforms, on which succeeding ones have built. The history of one horizon of life is that its own completion but prepares the way for a higher one, furnishing the latter with conditions of a still further development. Thus the vegetable kingdom died, so to speak, that the animal kingdom might live, having descended from an animal stage to subserve the function of food for animals. The successive types of animals first stimulated the development of the most susceptible to the conflict, in the struggle for existence, and afterward furnished them with food."

V. CATAGENESIS OF INORGANIC ENERGY.

If the principles adopted in the preceding pages be true, it is highly probable that all forms of energy have originated in the process of running down or specialization from the primitive energy.

In the department of physics I am not at home, and touch upon it merely to carry out to a necessary conclusion the hy-

pothesis presented in the preceding pages. It may be that physicists and chemists may find value in the suggestions which come from the side of biology. A cursory perusal of the general hypotheses current in these departments shows that the door is wide open to receive light from this quarter. What can be offered here is of the vaguest, yet it may suggest thought and research in some minds.

In the first place, it is highly probable that one of the problems to be solved by the physicists of the present and future, is that of a true genealogy of the different kinds of energy. In this connection a leading question will be the determination of the essential differences between the different forms of energy and the material conditions which cause the metamorphosis of one kind of energy into another.

In constructing a genealogy of energies, it must be observed that we will probably obtain, not a single line of succession, but several lines of varying lengths. It must also be remembered, that as in the forms of the material world which are their expression, a greater or less extensive exhibition of all the types remains to the present day.

That the tendency of purely inorganic energy is to "run down," in all except possibly some electric operations, is well known. Inorganic chemical activity constantly tends to make simpler compounds out of the more complex, and to end in a satisfaction of affinities which cannot be further disturbed except by access of additional energy. In chemical reaction the preference of energy is to create solid precipitates. In the field of the physical forces we are met by the same phenomenon of running down. All inorganic energies or modes of motion tend to be ultimately converted into heat, and heat is being steadily dissipated into space. Therefore the result has been and will be the creation of the mineral kingdom; of the rocks and fluids that constitute the masses of the worlds.

The process of creation by the retrograde metamorphosis of energy, or, what is the same thing, by the specialization of energy, may be called *catagenesis*. It may be denied, however, that this process results in a specialization of energy. The vital energies are often regarded as the most special, and the inorganic as the most simple. If we regard them, however, solely in the light of the essential nature of energy, i. e., power, we must see that the chemical and physical forces are most specialized. The range of each species is absolutely limited to one kind of effect, and their diversity from each other is total. How different this from the versatility of the vital energy! It seems to dominate all forms of conversion of energy by the mechanisms which it has, by evolution, constructed. Thus if the inorganic forces are the products of a primitive condition of energy which had the essential characteristics of vital energy, it has been by a process of specialization. As we have seen, it is this specialization which is everywhere inconsistent with life.

With these preliminary remarks we may now consider very tentatively the relations of the different kinds of energy to each other and to consciousness. In practice it is sometimes difficult to draw the line between conscious and unconscious states of energy. One reason is, that although a given form of energy may be unconscious, consciousness may apprehend the action by perceiving its results. The distinction is rendered clearer by the reflection that we can perceive by sight or touch any action of the body of whatever character. The energy of the conscious type is therefore altogether mental. The relations may be expressed as follows:

A. Designed (always molecular). Examples.

- I. Conscious.
 1. Involving effort. "Voluntary" acts.
 2. Not involving effort. Passive perception.
- II. Unconscious.
 3. Involving mental process. Unconscious automatic.
 4. Not involving mental process. Reflex.
- B. Not designed.
 - I. Molecular.
 5. Electric.
 6. Chemical. } Crystalline and non-crystalline.
 7. Physical. }
 - II. Molar.
 8. Cosmic.

The only strictly molar energies of the above list are the cosmical movements of the heavenly bodies. The others are molecular, although they give rise to molar movements, as those of the muscles, of magnetism, etc. Some molar movements of organic beings are not, in their last phases, designed; as those produced by nervous diseases.

The transition between the organic and the inorganic energies may be possibly found in the electric group. Its influence on life, its production of contractions in protoplasm, and its resemblance to nerve force are well known. It also compels chemical unions otherwise impracticable, thus resembling the energy of the protoplasm of plants, whose energy in actively resisting the disintegrating inorganic forces of nature is so well known. Perhaps this type of force is an early-born of the primitive energy, one which has not descended so far in the scale as the chemistry which holds so large a part of nature in the embrace of death.

Vibration is inseparable from our ideas of motion or energy, not excluding conscious energy. There are reasons for supposing that in the latter type of activity the vibrations are the most rapid of all those characteristic of the forces. A center of such vibrations in generalized matter would radiate them in all directions. With radiant divergence the wave lengths would become longer, and their rate of movement slower. In the differing rates of vibrations we may trace not only the different forms of energy, but diverse results in material aggregations. Such may have been the origin of the specialization of energy and of matter which we behold in nature.

Such thoughts arise unbidden, as a remote but still a legitimate induction, from a study of the wonderful phenomenon of animal motion; a phenomenon every where present yet one which retreats, as we pursue it, into the dimness of the origin of things. And when we follow it to its fountain head, we seem to have reached the origin of all energy, and it turns upon us, the king and master of the worlds.

REGENERATION OF THE SCALES OF THE GERMAN CARP.

By JOHN A. RYDER.

In the early part of 1884 a fine specimen of the German carp, of the mirror variety, was brought from the carp ponds to the Army Building, where it was placed in one of a number of large aquaria. Unfortunately, in handling the specimen, which is now nearly 18 inches long and 5 inches wide, one of the largest scales of the large lateral series was knock-

* *Revue Scientifique*, 1884, Jan., p. 2.

† See address of C. W. Siemens, Prest. British Ass. Adv. Science, 1882, *Nature*, 1882, p. 400.

‡ Says Mr. F. Peckham (*American Journal of Science and Arts*, 1884, p. 105), on the origin of bitumens: "These chemical theories (of the origin of bitumens) are supported by great names, and are based upon very elaborate researches, but they require the assumption of operations nowherewithin nature or known to technology. . . . In the chemical processes of nature complex organic compounds pass to simpler forms, of which operation marsh gas, like asphaltum, is a resultant, and never the crude material upon which decomposing forces act."

§ *American Naturalist*, 1880, p. 268.

* The term specialized, introduced into biology by Professor Dana, has been used in connection with energy in creation by the author, *Penn Monthly*, 1875, p. 569.

† Die Chemische Kraftquelle in Lebenden Protoplasma, von O. Loew u. T. Bokorny, Munich, 1882, 1.

‡ *Penn Monthly*, 1875, p. 574.

ed off, so that after a careful examination the writer expressed himself satisfied that the injury received by the fish was considerable, and that there could be no doubt that nothing of the scale remained, though it is probable that the "bed" or tissue from which the scale grew was preserved, but the outer investment of the scale was almost altogether gone. The scale in question was situated just behind the right operculum, and was nearly or quite an inch wide vertically.

Dr. R. Hessel, who was present when the scale was knocked off of the fish, picked it up and kept it. There is therefore no doubt whatever that it was wholly removed.

After about five months have elapsed, or at the time of the present, writing an examination shows that a new scale has been formed in the situation where the first one grew, similar in form to the old one, but apparently thinner, the outer skin investing it being also less densely pigmented than that which covers the scale in a corresponding position on the opposite side of the body.

When the scale was first lost the surface from which it had been removed was congested, though the irritation in the vicinity seemed to subside after a fortnight or thereabouts, so that but little evidence of the injury remained, except the whitish appearance of the skin where the scale was originally situated. It is still lighter in color, but is otherwise perfectly healthy, though the fish had been for a time infested with fungus, from which it recovered entirely, in spite of the fact that an abraded surface was exposed which would render it more liable to succumb to the invasions of the vegetable parasite.

To what extent the scales of fishes may be regenerated, and under what conditions, the writer is not able to say, but there is no doubt whatever that such regeneration sometimes occurs, as in the case cited above. Without taking the trouble to look up the literature relating to the regeneration of the scales of fishes, of which there does not, so far as he is aware, seem to be much, the writer has thought the foregoing well-authenticated case of the regeneration of these structures worthy of record, so that others might be profited in case it should be desired to investigate the subject still further. It is doubtless true that as in the case of the nails, where if the underlying epidermis or "nail bed" is lost the nail does not again grow out, so in the case of the fish, if the entire investment of the scale both internally and externally, was removed, the latter would not be formed again.

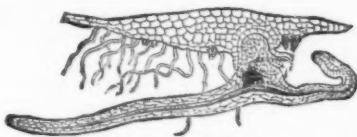
This observation has some slight practical value, since in the transportation of young carp it frequently happens that the scales, which, as in many fishes, are firmly embedded in the superficial layers of the skin, are accidentally removed in handling, even when considerable care is exercised, to the apparent injury of the individuals.

If it is true that under ordinary circumstances scales which have been lost without impairing the tissue from which they have been formed are again produced in the situation and of the same size as the scales which have been removed, then it is evident that such an injury is not very serious, even if not desirable, and that it will not very greatly interfere with the growth and health of the young fish.—*Bulletin U. S. Fish Commission.*

FERN SPORES V. SEEDS.

Would you kindly explain the difference between a fern spore and a seed?—*EMBRYO.*

If the seed of a bean be carefully cut open and examined, it will be found to contain the embryo—i. e., beginning—of a perfect plant, and in very large seeds a miniature plant may be seen by the naked eye. A seed may be likened to a fresh egg, which contains the embryo of a bird. In the case of a seed the plant is there ready to germinate, and its characters were formed long before the seed arrived at maturity, name-



Section of prothallus.

ly, when the ovule was fertilized by the pollen. The spore of a fern may be likened to a perfect flower, such, for instance, as a primrose. It contains in an as yet undeveloped state the organs which combine to produce a young fern. When a spore falls or is placed on any moist, warm medium, it begins to vegetate by emitting a little hair-like growth, which develops into a flat, leaf-like expansion resembling liver-wort (marchantia). On the under side of this green layer, which is called a prothallus, are developed little cells containing tiny coiled threads, and these threads possess the power of moving, or, rather, we will say, they move mechanically owing to the action of moisture on their coiled bodies. These are the fertilizing organs, analogous to the pollen of an ordinary flower. Close to the cells containing



Prothallus with sporangium.

these fertilizing organs little sacs or cells are formed, on the top of which something analogous to the style of a flower is developed. These are the female organs. As growth proceeds, the little threads or male organs reach the sacs or females, and fertilization takes place, and the first process in the formation of a new plant is thus completed. After this the young ferns begin to show themselves along the axis of the prothallus, and as they become strong enough to look after themselves the prothallus withers away. Sometimes several plants are developed by each prothallus, and when it is remembered that each prothallus is the product of a

single spore, it will be seen how widely different the latter is from a seed. The writer has divided a prothallus of *Todea superba* into a dozen pieces, and from each one a young plant has been obtained.

The peculiar nature of the reproductive organs of ferns may be seen in the large number of cases of spores having



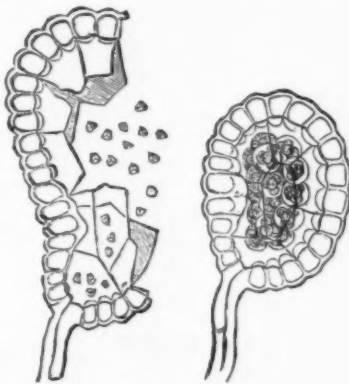
A, cell containing fertilizing organs; B, spiral fertilizing organ more magnified.

germinated freely, but failed to produce plants, and this failure is explained by the interference in some way or other with the process of fertilization. Sometimes one of the sexes is missing from the prothallus, and sometimes both sexes fail to appear. Instances have been known of the



A, longitudinal section; B, transverse section of a fertile sac or cell on the prothallus.

prothalli having lived and grown for several years without ever showing signs of developing plants. The hybrid ferns recently raised by Mr. Bausé and others are supposed to have been obtained through sowing spores of two species of ferns together, and thus bringing the sexes of the two kinds within reach of each other. All this beautiful ar-



Spore cases, showing how the spores are disengaged.

range can only be observed with the aid of a powerful microscope, but although we may not be able to follow the whole process through, we may yet see, by noting the results of fern spore development, that what science teaches us in this matter cannot be far from correct.—*B., The Garden.*

THE INFLUENCE OF HEAT AND LIGHT UPON VEGETATION.

DR. HELLRIEGEL has been engaged for some years in studying the action of heat and light upon the development of plants. His results, which are very important both from a practical and a theoretical point of view, were made the subject of an independent work,* and have also appeared in an abridged form in certain German periodicals.

He lays down the fundamental position that the stock of nutritious matter which is placed at the disposal of a plant is capable of being utilized and assimilated only when a given quantity of heat and light is simultaneously offered. The life of the plant lies within two well defined limits of temperature. These limits differ not alone for every vegetable species, but for each physiological function.

Near the lower limit of temperature all the vital functions of a plant are effected with extreme sluggishness; but as the heat augments the energy of vegetation increases, and reaches its maximum at a certain degree, which may be called the optimum temperature. If this limit is overstepped, the vital actions of the plant become feebler again—probably by reason of abnormal processes and decompositions in the interior of the cells—and cease entirely at a third upper limit.

The optimum temperature for the different physiological functions ranges between 68° and 104° F. (20° to 40° C.); temperatures above 123° F. (50° C.) have a destructive action upon the more highly organized plants.

Light behaves in a manner very similar to heat. In complete darkness, no green (chlorophyllaceous) plant can pro-

long its normal existence. The germinative process alone is effected better in darkness than in the light. If a plant which has passed this stage is completely secluded from light the formation of chlorophyll is prevented, and any which has been previously formed is destroyed. The plant becomes pale, the stem and leaves assume a quite anomalous form, and the amount of total dry matter decreases.

The most important phase of the nutrition of plants, the decomposition of carbon dioxide (carbonic acid) and the assimilation of the carbon in the chlorophyllaceous cells, is purely a function of light, in other words, it increases or decreases with the increase or decrease of light.

In a faint light the process of assimilation is feeble and tardy; it increases with the intensity of light and reaches an optimum point, which, however, does not coincide with the maximum of light. Heat and light, together with the rainfall, form that complex factor in fertility which is understood by the terms "weather" and "climate." This factor determines the quantity of crops more frequently, and to a greater degree, than the natural factor known as fertility of the soil, and the artificial factor of manures.

It is generally supposed that the lowest limit at which the majority of our field plants are capable of germinating is about 39° to 41° F. (4° to 5° C.). Observation, however, proves that this limit lies lower, approaching 32° F. (0° C.).

To decide this point, Dr. Hellriegel, in the winter 1871-72, sowed the seeds of eighteen plants which he wished to study in a number of flower-pots. No. 1 was kept at the constant temperature of 87° C., No. 2 at 5°, No. 3 at 3°, No. 4 at 2°, and No. 5 at 0° C. The soil and the proportion of water were alike in every case. In this manner the pots were allowed to stand for 55 to 60 days. The temperature of the soil was determined at different times of each day, and the number of seedlings was noted.

At the end of the experiments the young plants and the seeds which had not germinated were washed out of the soil, and more closely examined. The seeds experimented on were winter rye, winter wheat, barley, oats, maize, rape, flax, tares, peas, horse-beans, clover, carrots, cress, and cucumbers. Winter rye was found to require the lowest temperature for germination. It sprouted at 32° F. (0° C.) quite normally, and developed both its seed-leaf and root-germ, though slowly. Winter wheat came next; it germinated at the same temperature, though more slowly than rye. Barley and oats required more heat; they put forth their seed leaf at 35½° F. (2° C.), though the root showed at 32° F. Maize, as might be expected, required the highest temperature among the cereals; it only began to germinate, and that slowly, at 47½° F. (8½° C.).

Rape germinated at 32° F.; flax at 35½° F.; tares sprouted well at 32° F.; peas and clover at 35½° F.; beans and carrots at 37½° F.; while cucumber seeds showed no signs of germination even at 47½° F.

It must not be supposed that these results throw any light upon the temperatures required for the further development of the different species of plants. Further experiments were made in this direction with barley seedlings. A series of flower pots was taken, of which *a* was kept constantly in a water bath at 50° F. (10° C.), *b* in one at 68° F. (20° C.), *c* in a similar bath at 86° F. (30° C.), *d* in one at 104° F. (40° C.), and *e* stood in a water bath exposed to the fluctuating temperature of the atmosphere. In each pot were set two barley seedlings, the soil and the water supply being of course identical in every case. The experiment was continued from August 9 to November 9, when the plants were pulled and analyzed.

The plants in *e* showed a healthy, equable growth, and a good color, and were evidently quite normal. Very similar were the plants in *b* (at 68° F.). Those in *a* grew unusually slow, while the plants in *c* grew very rapidly. The former of these two lots, however, were of a deep luxuriant green, while the latter were duller and paler in color. The plants in *d*, exposed to a constant bottom heat of 104° F., were pale and sickly, and lagged behind in their growth. This temperature had evidently an injurious effect. For barley, therefore, a temperature of 68° F. seemed the optimum point, while 50° and 86° F. could not be pronounced hurtful.

Similar experiments were made with the seedlings of other cereals. It was found that wheat, in its first period of growth, requires a considerably higher bottom heat than rye, a result which agrees substantially with observation made in the fields in ordinary agricultural practice.

For rye in the first period of growth, assimilation was found to be most active at 68° F., for barley 77° F., and for wheat at 86° F.

The question was next raised whether, and if so to what extent, transitory higher temperatures affect the growth of plants injuriously.

The various physiological functions of vegetable life are not all best effected under the same conditions of heat and light, but require unequal quantities of both. Thus the respiratory process—till lately very frequently overlooked in plant life—requires the smallest share of heat, and goes on even in the total absence of light. The assimilation of carbon makes higher demands both for heat and light, while the formation of certain chemical compounds requires a still more liberal supply of both.

These and other single physiological functions obtain a varying importance for the general life of the plant at its different vital epochs. Hence, as a necessary inference, the entire plant requires at its different stages different quantities of heat and light. As a general rule, as a plant approaches and reaches maturity, the more heat and light it requires. If the maximum intensity of heat and light does not coincide with the last period of the plant's life, but with the epoch of the most active production of leaves, the total growth is checked; the production, and consequently the development of the seed, is retarded.

If in this last period the supply of heat and light is insufficient, the reserve matter which has been accumulated in the leaves does not translocate completely to the seeds, but remains to a greater or less extent in the leaves, in the stalks, and in the seed capsules. Hence the leaves do not wither, but remain green and juicy. In bad cases new shoots are pushed out, and the crop never ripens.

As the intensity of light and heat increases regularly from winter to summer, and reaches its maximum from July to the middle of August, the vegetative times of plants should be so arranged that the epoch of the formation of seed may fall about the end of July. The seed times for the different crops are therefore dictated neither by custom nor by economic circumstances, but by natural laws, the relations of the plant to the earth's annual movements.

It is therefore evident that the productiveness of a country depends not so much on its mean temperature as on the question whether its supply of heat is received at the right time. It has been demonstrated by other observers, proceeding by the statistical method, that, other things being equal,

* Beiträge zu den Naturwissenschaftlichen Grundlagen des Ackerbaues, Braunschweig.

the wheat harvest in England is simply a function of the mean temperature of the months of July and August, unusual heat after harvest or in winter being, as far as corn-crops are concerned, simply wasted.

Dr. Hellriegel illustrates his conclusions as to the coincidences of the epoch of maximum heat with that of the formation of seeds by the following experiments: He sowed barley, under otherwise identical conditions, on April 21, May 28, June 28, August 2, and September 1. The first crop became ripe in 88 days, the second prematurely ripe in 87 (the maximum heat and light happening too early, before the plant was sufficiently mature), the third became imperfectly ripe in 150, the fourth in 200, and the last in 240 days!

In another series of experiments Hellriegel examines the comparative action of direct and of diffused light upon plants. He points out certain disadvantages to which plants cultivated in glass houses are exposed. The motion of the air in an inclosed house is less perfect than outside (though it must be admitted that in England generally the movements of the air are far too perfect for vegetation). Another—and in our opinion far more important—difficulty is that even the best glass is not absolutely permeable to air and light, a certain portion being reflected or absorbed. Within the house a further portion of the light which has entered is absorbed by dark objects (plants, pots, soil, etc.), and converted into heat which does not radiate out at the same rate as it is produced. Thus the proportion between light and heat is different within from without; we hesitate, however, to indorse the author's opinion that this difference in proportion is always disadvantageous to plant life. The proportion existing in the open air varies exceedingly, and there are few conditions more destructive to plant life than one which prevails very commonly during the easterly winds of spring, when intense light is combined with a low temperature. It has been found that the blighting effect of such weather may be counteracted either by increasing the heat or by keeping the plants temporarily in the dark.

From Hellriegel's experiments it appears that from two sets of barley plants, equal in number, those cultivated in direct sunlight in the open air gave 4,283 mgrms. of grain, while a similar number grown in diffused light only yielded merely 873 mgrms.

A further subject investigated was the development of plants in light of different colors. The author's results by no means confirm those with which General Pleasonton astonished the world a few years ago.

It is a known fact that white light, after it has passed through our atmosphere, has not always the same qualitative composition. The author did not attempt to experiment with perfectly homogeneous, monochromatic light, but selected illuminations in which rays of a certain given wavelength predominated, others being more or less completely excluded. For this purpose he used very large roomy bells of colored glass, which were kept regularly ventilated by means of a petroleum lamp. Under similar bells of colored glass, plants had been found capable of passing through their entire vital cycle without displaying any anomalous phenomena or yielding unusually small crops.

To determine the influence of different colors of light two bells were selected, the one of blue and the other of yellow glass, both of a medium shade.

The blue glass, colored with cobalt—as was found on examination of its spectrum—transmitted, in addition to the blue and violet rays, the red and the green, apparently unaltered, the orange and yellow only being extinguished.

The yellow glass, colored with carbon, transmitted all the rays except the blue and violet. The absolute intensity of the light was manifestly greater under the yellow bell than under the blue.

The barley plants under both bloomed normally, formed good, perfect ears, and ripened finally in the ordinary manner without being distinguishable from other plants placed for comparison under a colorless bell.

The weight of all parts of the plants above the surface, when dried, was from the yellow bell 5,291 mgrms., and from the blue bell 4,431.

Two new pots of equal size were then planted with sprouting barleycorns, and placed under colored bells. The blue bell was of the same color as in the former experiment, while the yellow bell was darker, and the absolute brightness under it was small. The violet ray was quite extinguished, and the blue nearly so. Both plants showed nothing anomalous in their growth which might be ascribed to the specific action of the colored light. They seemed merely like plants which had been partially withdrawn from the direct sunshine. There was no difference between the two, save that the plant under the yellow bell, which was the darker of the two, was the earlier in showing signs of weakness. The plant from the yellow bell gave 2,572 mgrms. of dry substance, and that from the blue bell 2,790.

It thus appears that plants are not very sensitive to moderate changes in the qualitative composition of the sunlight to which they are exposed.

It need scarcely be added that the wonderful effects which have been ascribed to the blue ray, or rather to light passing through ordinary cobalt-blue glass, cannot be considered as scientifically demonstrated.—*Jour. Science.*

THE INFINITELY GREAT AND THE INFINITELY LITTLE.

By RICHARD A. PROCTOR.

At first there is a sense of relief in turning from the vast depths of star-strewn space to contemplate the minute, as revealed by the microscope. One may be said to pass from the infinitely great to the infinitely little. Even the domain of the telescope, though really finite, is for us practically infinite; moreover, the domain of the telescope is obviously but the threshold of a far vaster domain beyond; every increase of telescopic power has shown more and more stars, and more and more of that filmy luster which indicates the presence of stars beyond telescopic range. In like manner the microscope reveals the infinitely minute, or what is practically such for us; while manifestly the range of the microscope toward minuteness is but a step toward that ultimate structure which may be regarded as representing absolutely infinite minuteness. Every increase of microscopic power has shown more and more minute details of structure. No astronomer supposes for a moment, now that he has learned so much of the vastness of space, that he can ever know of more than the merest point in extent compared with the infinity which is; no microscopist hopes that he can ever even approach the recognition of the ultimate structure of the objects which come under his scrutiny. We have in fine the same oppression of infinity in studying the minute as in studying the vast.

But this lesson has its parallel when we consider the realms of time, and when we consider the bearing of what we study in our recognition of law throughout the universe. We cannot but perceive that with increase of scale—to consider that point alone, for the moment—comes (on the whole) increase of the duration of the various processes constituting what may be termed lifetime. The duration of the animal is far shorter than that of the world, the duration of the world far shorter than that of a system of worlds, the duration of the system of worlds far shorter than that of systems of suns. And as with the duration or totality of life, so is it with the processes belonging to life; the circulation of an animal's blood, the rotation of a planet, the cycles of planetary revolution, the movements constituting what may be termed the circulation of a galaxy of suns—these various processes extend longer and longer in duration, the larger the region of space constituting the domain of that which exhibits them. So, in turning to the minute objects revealed or in part interpreted by the microscope, so far as we can follow these we see that (speaking, of course, with the broadest generality) the minuter objects have the shorter lives and the most rapid life-processes. While on the one hand we have evidence of material life lasting for periods which to us are practically eternal, we see on the other hand creatures whose whole lives pass before us so quickly that mere instants must be assigned to the indiscernible life-processes belonging to such creatures. Beyond the range of our telescopes on the one hand and of our microscopes on the other, we see "Actual Eternity" and the "Real Instant" as certainly, though we can conceive neither, as we see the infinitely vast and the infinitely minute, which are equally beyond our powers of conception.

But strangely enough, while all who think at all are ready to admit that the study of the vast and the minute bring before us as realities the mysteries of the infinitely great and of the infinitely small, of infinitely long and infinitely short duration of time, many do not seem to admit, or even to consider it right to admit, the extension of law to the infinitely great or small in extent and in duration. No man now rebukes the astronomer for asserting that the universe is infinitely vaster than that which in former ages men supposed to be the universe, nor is any one troubled (at least, I suppose not) when the microscope reveals millions of millions of tiny objects and minute forms of life of which men in former ages knew nothing, and which in no sense entered into their ideas of creation. So—but perhaps not quite in the same degree—with regard to time: I suppose it may be truly said now that no one with competent power of thinking refuses to recognize the evidence of a practical infinity of time past and to come, during which even that which *is* has existed, or, on the other hand, to admit that in the duration of a single breath lives begin and end of whose very existence men in past times had no idea. But to extend the operation of law to the vast and the minute, in space and in time, is regarded by many as absurd, if not wicked. They cannot seemingly understand that there is nothing more remarkable in the operation of law throughout infinity of time and space, and down to the minutest atoms of matter, than there is in the operation of law on a scale more within our scope. If we admit that a tree grows from the seed, or an animal from the germ, we need not be surprised to find evidence that a world or a system of worlds grows in like manner, or that the tiniest creatures have been developed, even as science recognizes that the various kinds of animals and plants have been developed, through multitudinous phases of evolution. At a first view it may seem that in some of the wonders of minute life, the eye of a fly, the tongue of a moth, and so forth, we have objects presenting great difficulties in the way of the general doctrine of evolution. How, it may be asked, could a fly's eye, with all its thousands of separate facets (or rather eyes), have been developed? Yet so soon as we consider how it has actually formed, under the very eyes of science so to speak, we find a mystery quite as overwhelming as the mystery that that very process of formation is itself a development, or the still more impressive mystery that evolution itself, as science deals with it, is a product of a higher process of development.—*Newcastle Weekly Chronicle.*

THE FARMER'S POSITION.

We understand well enough that farming is not a life of ease, nor are farmers constantly lying on beds of roses. It means work. It means business, and, if successful, it means energy, enterprise, forethought, and skill; and for that matter, so does every other. That is what we are here for, and that is what our Creator gave our faculties for. It does me no good to have Vanderbilt held up. There is only one Vanderbilt among more than fifty millions of people, and if he is any happier than I am, it is not because of his wealth, but in spite of it. Let us look for a moment at some of these monopolies. Take, for instance, the cotton print manufactures. They are sending out goods for five cents a yard. One dozen eggs will purchase four yards. It does not appear to me that the farmers are very severely preyed upon by them. Three good lambs will purchase a very respectable suit of clothes. Was this ever the case before? Do the importers of sugar bear hard upon the farmers when it can be purchased at present prices? The list can be extended to almost the entire expense of the household. Does the farmer find fault or have any occasion to find fault with the price he can get for his oxen, his horses, or any other products of his farm? If so, I ask him when the money received for such products would ever purchase so much of the needed supplies for his family use?—*Maine Farmer.*

A STARTLING POTATO YIELD.

The editor of the *Rural New-Yorker* reports a yield of potatoes upon its experiment grounds of 1,391½ bushels per acre. They were dug Aug. 27, weighed, and the yield per acre figured out by disinterested parties. We are not informed as to the size of the field, nor much about the method of culture. This is at the rate of 8 bushels and 41 pounds per square rod. With rows two and three-fourths feet apart (33 inches), there would be six rows to the rod. The above yield would give five pecks and nearly seven pounds to each row one rod long. With the hills sixteen and a half inches apart there would be twelve hills to the row, and almost seven pounds per hill, or a small fraction less than a half peck. There is plenty of room on an acre of land to bury 1,390 bushels of potatoes, but not many farmers have yet learned how to coax that quantity to grow upon so small an area. It is worth something to know that it can be done. Four hundred and eighty-eight bushels was our largest yield of this crop, estimated from the product of one square rod. We are anxious to try again, and intend to do so.—*N. E. Farmer.*

DR. LARDNER AND TRANSATLANTIC NAVIGATION.

THE late Dr. Lardner gave an emphatic denial to the statement that he asserted Atlantic steam navigation to be impossible. He says that at the British Association meeting in 1836, he advocated one of the projects. At p. 118, vol. x., of the *Museum of Science and Art*, appears an extract from the *Times* of 1837, showing his ideas on the subject, which were simply that too much should not be immediately expected, and that caution should be used. I do not know if he ever held a different opinion, but if not I consider it only fair to his memory to notice these facts. He adds: "What I did affirm and maintain in 1836-7 was, that the long sea voyages by steam which were contemplated, could not at that time be maintained with that regularity and certainty which are indispensable to commercial success, by any revenue which could be expected from traffic alone, and that, without a Government subsidy of a considerable amount, such lines of steamers, although they might be started, could not be permanently maintained." He then goes on to notice what was the actual subsequent fate of the earliest Atlantic steamers, which quite corroborates what he had advanced. He likewise mentions that, "long antecedent to the epoch now adverted to, the Atlantic had actually been crossed by the steamers *Savannah* and *Curacao*."

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